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Devoted to the interests of the engineers and technical officials of the cities, counties and states

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TIMEWASTERS

Our special sports problem involving the fox with the strong scent and the dog with the delicate nose has brought quite a flood of solutions—some of them correct. After wishing us a Merry Christmas and a Happy New Year, John Howard Anderson says: "During the interval between the elapsed time of 28.5366 seconds and 30 seconds the dog was able to detect a faint whiff of the fox for 1.4634 seconds. The whiff was exceedingly faint, for when the two were the nearest together (elapsed time of 29.2683 seconds) the distance was 3298.39 feet. This problem is unusually good as the rate of change of the curve is too small for cut and try methods." And Mr. Wheeler: "This dog-gone fox story had me going for a time but I'll bet I wasn't alone. Boy, oh boy, what a problem. That fox smell must travel it in next to nothing—faster than light from the stars. . . . Thank you very much, Mr. Blunk. May you originate another one as good." And Mr. Blunk sends in a slight correction to his original solution, which brings him in line with Messrs. Anderson and Wheeler.

The answer to the alphabet problem is 40 minutes, or two-thirds hour. The solution is perhaps facilitated by converting the time factors to minutes.

Credit to Whom?

Another fox problem which we clipped from a magazine, and then forgot what magazine; we hope the publishers will pardon us for this lapse of memory; also for suggesting that instead of a fox it was a bear. Here it is: Two hunters, wishing to determine the weight of a fox they had caught, balanced a plank on a fence and then balanced each other on the plank. They then exchanged places. but this time the lighter man held the fox in his lap. They found that the plank balanced again. One hunter weighed 150 pounds; the other 180. What did the fox weigh? Too easy for our gang.

Thank you, Mr. Bevan:

If it is now between 10 and 11 o'clock, and 6 minutes hence the minute hand of the watch will be exactly opposite the place where the hour hand was 3 minutes ago, find the time.

Thank you:

As we begin a new year, something like the sixth for Timewasters, we wish to thank the many readers who have contributed of their time and brain power. We have enjoyed very much hearing from them and reading their letters; we hope we meet more of them personally in the future. Also we wish to thank the many who have contributed problems; without their help, which we ask for the future, this column could not have carried on. W. A. H.

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A. PRESCOTT FOLWELL, Editor — **W. A. HARDENBERGH**, Asso. Editor

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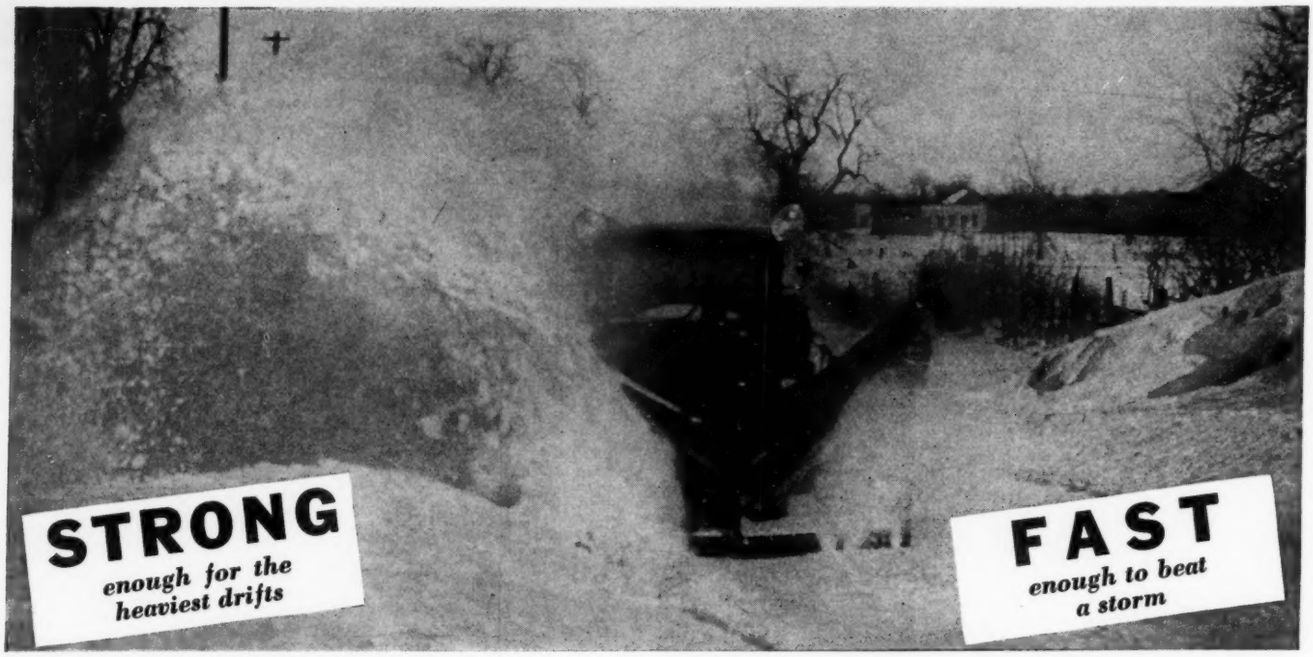

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PUBLIC WORKS

City, County and State Engineering and Construction

Vol. 68 *January, 1937* No. 1

Roadside Development for Counties—II

Tree Planting on County Highways

By F. M. GUIREY

Landscape Engineer, Arizona State Highway Department

TREE and shrub planting and maintenance of the same constitute two of the most interesting and important phases in a program for roadside development. Because the preservation of existing growth is one of the first considerations in landscaping a highway, let us take it up first.

Existing trees fall readily into several general classifications: trees which need little or no additional treatment; trees which are filled with dead wood and sucker growth; trees which have grown too closely together; trees which have been mutilated through improper trimming, and trees in such a state of decay that trimming or other mean of rehabilitation are too expensive to be economically sound.

Existing Trees

However, before doing anything, a careful analysis should be made to ascertain what of the existing growth is desirable for saving. As you drive down the road, note mentally which trees give pleasant shade, which ones serve to screen off unsightly objects or to frame pleasing vistas, direct traffic around curves, relieve an otherwise monotonous skyline, accentuate points of interest, etc. These trees are all well worth saving.

On the other hand, note which ones are so close to the shoulder (say nearer than seven feet) that they constitute a real traffic hazard; those which block vision on the inside of curves, obstruct intersection sight distances, hide pleasant vistas, lean at such an angle that in a high wind they are liable to fall across the road, or are growing in such a way that they are breaking up pavement or concrete drainage structures. Trees of this type should be removed. Where decision is difficult, the landscape engineer for the state in which you are working usually can help to work out a satisfactory solution.

Now we are ready to look over the trees which we have decided to save. For trees that are desirably located and in such a state of preservation that attention is unnecessary, three rousing cheers should be given. In the case of trees which contain dead wood and suckers, the first thing to do is remove all of the dead wood. Tree saws, and for small branches, pruners, should be used. Never use an axe, for invariably splitting and marring of the tree results. The use of climbing spurs should be prohibited, for they tear up the bark, leaving it open to infection. Ropes should be employed in the removal of large branches, to prevent injury to both the workers and the tree. Furthermore, all men working aloft should be required to wear safety belts as a precautionary measure, for occasionally the branch on which a man is working will give way, letting him in for a nasty fall. For

The old man of the woods waiting for a hair cut. While this tree contained a great deal of dead wood it was such a fine specimen that it warranted saving. The lower brush and sucker growth was removed first, following with the large dead branches in the upper part.

What a difference! Without his beard the old man looks actually respectable. This shot was taken early the following spring. With the coming of summer many of the bare limbs will be partially covered with new growth, eliminating the present parachute-like appearance.

outside work, ladders are more satisfactory than working in the tree proper, as they take most of the weight of the man, lessening his chances for falling. It is also a good idea to start at the bottom and work up, rather than from the top down, for there is less danger of debris collecting in the lower part of the tree and fouling other branches or workmen.

The proper procedure in large branch removal is this: First make an under cut on the outer portion of the branch, approximately three feet from the main body or trunk, as the case may be. This will prevent stripping back of the bark when the branch is finally severed, and also eliminate splitting back into the main body. Next, make a cut down from the top six inches to a foot farther out from the main body. When the branch has been finally removed, you will have a stub approximately three feet long. This should now be undercut next to the main body to prevent bark stripping, and finally removed by means of a cut made parallel to the body of the tree, and just as close to it as possible. Never leave a stub on a tree. It retards healing of the bark, and is an excellent source of infection. Torn, broken or bruised places in the bark should be removed by means of a long, pointed, oval-shaped cut. A sharp knife is the best tool for thin barked trees, while a chisel and mall may be necessary for those of heavier bark. While this method increases the size of the exposed area, it helps the sap flow around the wound, and promotes faster healing than would be possible with a smaller irregular opening. It is also a good idea to paint all fresh cuts with a solution of Bordeaux mixture and linseed oil. This will effectively seal the wound against excessive drying and spore infection. Being poisonous, it also keeps out borers and harmful insects.

With the dead wood removed, now study the tree with a view to preserving its proper shape and balancing it up. Remember that each variety of tree has its individual characteristics, and that it is through these characteristics that the different varieties achieve their charm. Think of a world in which all the trees would look exactly alike! Consequently do all you can to preserve these characteristics. If a tree is naturally scraggly, do not attempt to trim it into a compact ball. Furthermore, highway trimming need not be as complete as the tree surgery performed on trees in your own yard, for the travelling public will pass most of this growth at a speed of somewhere between forty and sixty miles an hour. Growth which is badly crowded should be carefully thinned by the removal of undesirable, spindly growth, most of which would never reach maturity anyway. Also the removal of lower branches will greatly increase visibility and decrease fire hazard. In thinning, care must be taken to avoid excessive thinning the first year, for trees suddenly exposed to the sunlight are liable to scald, and are also subject to wind damage, as crowding has retarded the normal strength and development in their branches and trunks. It is sometimes necessary to thin slowly over a period of years, rather than all at one time. Trees may often be effectively thinned or headed up to afford a view of, say, a river, or, possibly, a valley that has been obscured previously. Trees that impair sight distance may likewise be treated to lengthen the view of the road ahead—particularly true on the inside of curves.

Where trees have been mutilated by trimming for wire clearance, etc., they may sometimes be reshaped, trained around the wires so that they will cause no further harm. Side-arming of lines and heading up of the trees are also effective means for obtaining clearance. When trimming of any type has been properly performed, very little trimming in the future will be necessary. In fact, trees, when left to their own devices, seldom give any real trouble.

One thing more on this subject. In many portions of the country there is a prevalent idea that everything over ten feet high must be "topped." The prime ass that invented this system of mutilation would have done the world a service by dying shortly after birth.

It is only in rare instances that topping is necessary, and then it should be done by an expert—not a "specialist." People say that there is danger of a tall tree's blowing down, but how often do you find examples of serious breakage in a tree that has never previously been trimmed? Usually only in the case of a hurricane, or when struck by lightning. The reason for this is that nature has very adequate means of providing protection for her own. Where you do get into trouble, though, is in leaving exposed ends or stubs open to infection. Various kinds of rot then enter the trunk through the stubs, eventually weakening, or even killing the tree.

It is well to remember at this point that all trees are not worth saving. Those that are too badly rotted or have too much dead wood to make trimming worth while should be removed, for while tree surgery might be employed to save them if they were on a private estate, the costs of such methods for highway work are prohibitively high.

What has been said about trees may well be applied to shrubs, with an added bit of advice to remove weeds adjacent to them as a means of fire prevention.

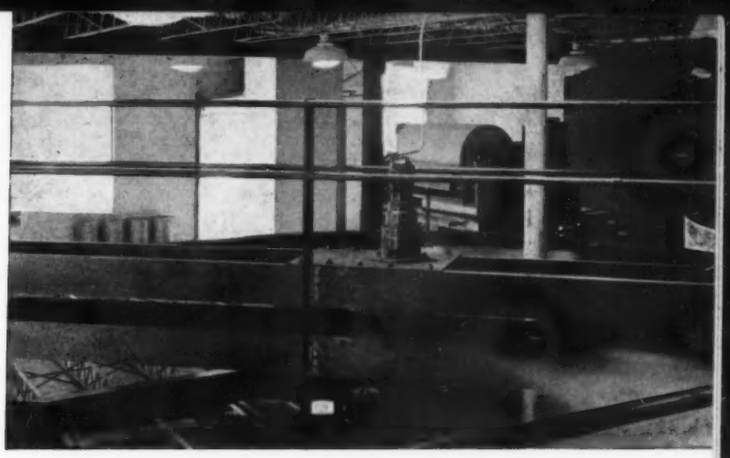
(*To be continued*)

A Simple Rain Alarm

A maintenance superintendent of the California Highway Department, C. T. Warren, says, according to "California Highways and Public Works," that one of his crew foremen has invented an ingenious device to roust himself out of bed when a storm of rain blows up and the highways become unexpectedly slippery and dangerous. He has attached to the eave of his home an empty coffee can so balanced that when rain water pours into it the can falls upon two contact points completing an electric circuit that rings a bell in his bedroom. When this occurs, the foreman gets up, dresses and goes out into the wet night to patrol his sections of road.

ROADS IN THE MISSOURI OZARKS
In the view on the right the black jack oaks help greatly in defining the outside of the curve, but the trees on the inside should be selectively thinned and headed up to increase sight distance, as has been done in the view on the left. Both pictures show the excellent results obtained by preservation of existing growth.

A 1936 Model Sewage Disposal Plant



Foreground—Top of one of the clarifying tanks. Rear—Vacuum filter.

By RAYMOND A. ORPUT

ST. CHARLES, Illinois, a city of 7,400 inhabitants, has completed recently a sewage treatment plant designed by A. R. Putnam, of Valparaiso, Ind., of the same general type described in PUBLIC WORKS for November, 1934, but of greater capacity and containing several later improvements. The treatment is complete, nothing leaving the plant except an excellent effluent, and products for which a sale is assured. And the entire plant is enclosed in a one-story and basement building 78 by 66 feet, of ornamental brick construction.

On entering the building the sewage first passes through two commutators, each of which is operated by a 1 hp motor, which reduce all solids to precipitable fineness and return them to the sewage, which then falls into a pump pit. From this it is lifted, by two vertical centrifugal pumps in a dry well, to a mixing trough just under the roof, where it receives milk of lime and carbon, and passes to two mixing tanks provided with horizontal-shaft paddles. Passing over a weir 11 ft. above tank bottom, receiving a dose of coagulant (ferric chloride) at the same time, the sewage flows through a 12″ pipe to two clarifying tanks. From these the clarified liquor flows onto "aerator pans" supported above five filters, through the holes in which it "rains" onto the filters, and passes through these and into an effluent storage well, where it is chlorinated and then discharged into the stream. Water for backwashing the filters is pumped from this effluent well, and the dirty wash water flows to a backwash well (underneath the mixing tanks), from which it is pumped into the mixing chambers.

The sludge settling in the clarifying tanks is drawn off by hydrostatic pressure into a sludge storage tank. Here it settles, the supernatant being drawn off into the backwash well and the sludge being pumped to an Oliver vacuum filter. The filter cake is carried by conveyor belts to a retort, where destructive distillation takes place, the sludge being subjected to a three-stage distillation process with temperatures of 900°, 1500° and 150° respectively and reduced to a carbon and a distillate. The gas given off during distillation is used in firing the retore. The liquid distillate makes an effective insecticide when diluted 20:1. The carbon is ground to 200 mesh in two motor-operated pulverizers and part of it used in treating the sewage (as described later) and the surplus is sold.

The plant has a capacity of 1 mgd, producing 2,000 lb. of sludge of 70% moisture content, which in turn produces about 600 lb. of carbon and 150 gal. of distillate.

In addition to treating sewage, the plant is planned to dispose of garbage also, being provided with a garbage grinder, the output of which goes to the backwash well, where it mixes with the filter wash water and the supernatant from the sludge storage tank, the mixture being passed through the entire treatment process with the raw sewage. About two tons of garbage a day is being disposed of.

Some Details

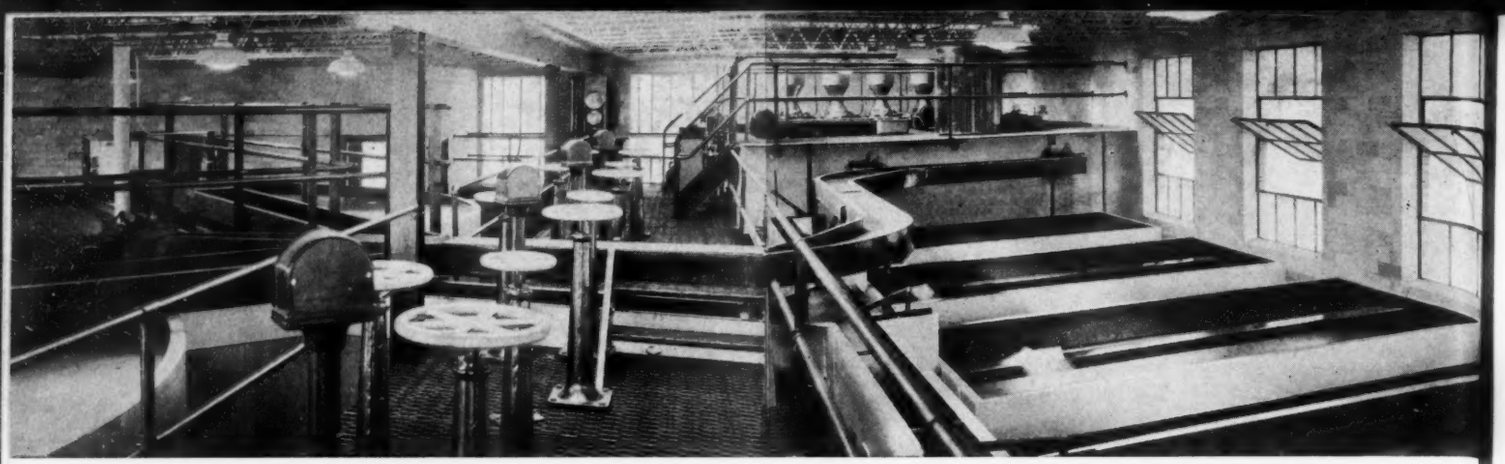
The lime and carbon are fed by International Filter Co. feeders, each proportioned to volume of sewage; the chief purpose being to arrest putrefaction and remove gases and odors.

The mixing chambers have paddles on top and bottom, designed to pull the incoming sewage directly to the bottom and complete a thorough mixing.

The two clarifying tanks are of special design. Each is circular, 20 ft. in diameter and 23 ft. deep, with the cone-shaped bottom inclined 30° from the vertical, terminating in an 8″ pipe through which the sludge is drawn off. A vertical partition extends from the top down 10 ft., to the beginning of the hopper bottom; it is located 7 ft. from one side, the smaller part receiving the sewage and the larger acting as a clear chamber. An overflow weir trough crosses the tank on the diameter parallel to the partition. A vertical shaft carries a set of four scraper fins in the bottom of the hopper, which make one revolution an hour. The entire tank and partition are of steel plate. These tanks are said to effect removal of 98% of the settleable solids.

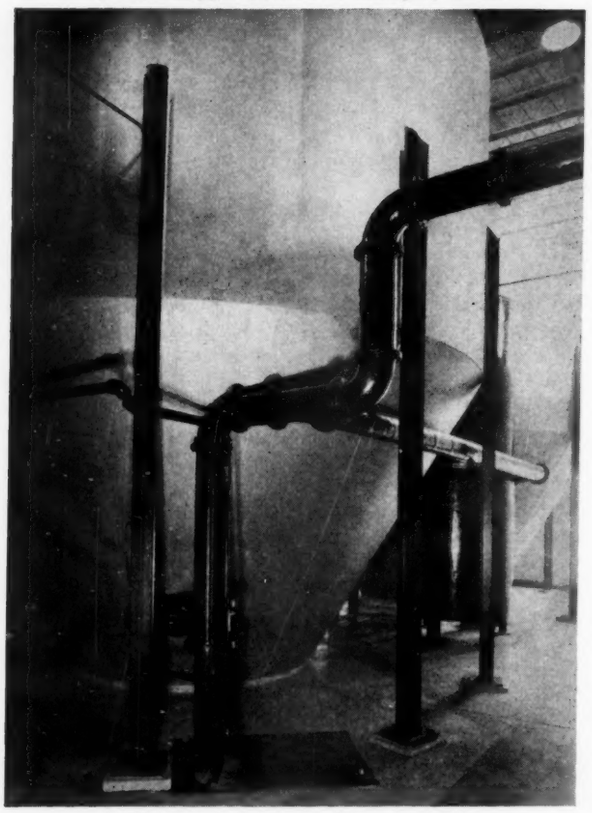
The filters are 8 by 16 ft., containing 16 in. of sand and gravel, on which is a quilt of the pulverized carbon about 1/16 in. thick is deposited by the sewage (being that fed to it in the mixing trough). The aerator pans are perforated with ⅛ in. holes spaced 1 in. c. c. The rate of filtration is regulated by rate-of-flow controls, being limited to 2 gpm per square foot. Mr. Putnam states that the chlorinated effluent, after treatment with 2 ppm of chlorine, has a residual of 0.2 ppm; also that the B.O.D. of the effluent ranges from 12 to 4, and the suspended solids from 12 to 2 ppm.

Front of building which contains treatment plant.



Left—Top of the other clarifying tank. Right foreground—Aerator pans above filters. Right rear—Mixing tanks and chemical feeders. Winding across the center, the trough carrying dosed sewage to tanks. Center, from front to rear, the operating gallery.

Below—Hopper bottoms of clarifying tanks.

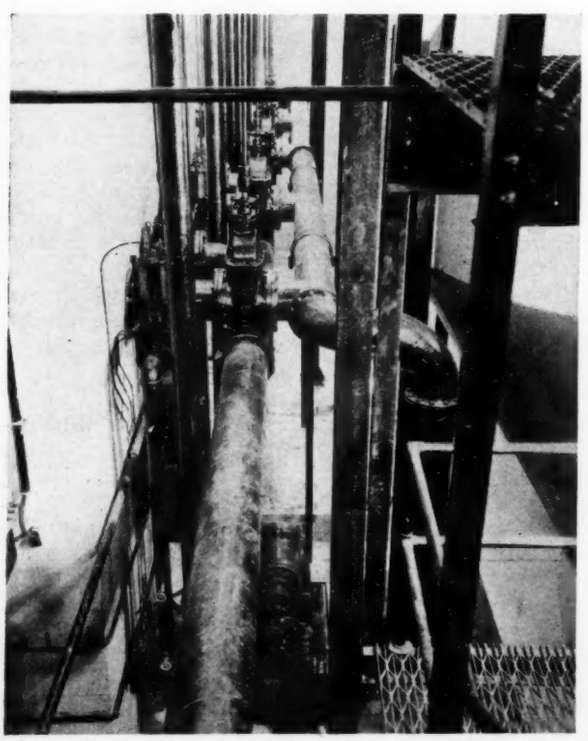


The plant is arranged with ingenious compactness. The clarifying tanks in the center of the building extend from the lowest part of the basement to an elevation about 6 ft. below the roof, but all other features are arranged in two or three tiers. The backwash well is under the mixing tank and a small locker room, while above the latter, in a third tier are the mixing trough and the lime feeder. The effluent storage tank is under the filters. The vacuum filter is on a floor which serves as a cover to the sludge well and retort room. The garbage grinder is underneath a charging floor at ground level. The commutators are above the sewage well.

The cost of the plant was about $76,000. Between 200 and 300 pounds of lime, about 150 pounds of ferric chloride and 200 pounds of carbon are used per million gallons of sewage. One man per shift can operate the plant. During the first 38 days an average of 116 kwh per day was used in treating 862,000 gals. This is used for pumping the crude sewage and backwash water to the mixing tanks (from which it flows by gravity through the plant to the outlet); in pumping the filter wash water; in pumping the sludge from sludge well to vacuum filter; in operating the paddles in the clarifying tanks and mixing tanks, the garbage grinder, the retort, the carbon grinder, and the vacuum filter.

The carbon is furnished by the plant itself, as is the gas used in the distillation. As the entire plant is housed inside a building, and no part of the sewage stays in the plant more than a few hours so that there is no putrefaction; and as the building is architecturally pleasing and it is proposed to landscape the surroundings, it is believed that there is no objection to placing such a plant wherever desired.

Mr. Putnam claims for this process and plant that it is a direct departure from the conventional biological setup. It demonstrates conclusively (1) that these wastes can be handled in a manner whereby obnoxious odors are eliminated, (2) that the garbage and sewage can be handled in the same plant and the solids converted into useful and valuable by-products, and (3) that industrial wastes hold no alibi for the process.



Filter tanks and effluent storage on left; clarifying tank on right. Upper right-hand pipe for wash water; lower left-hand pipe for wash waste.

A New Pitch Filler for Paving Blocks

By GEO. E. MARTIN
Consulting Engineer, General Tarvia Department, The Barrett Co.

COAL tar pitch has been used extensively for filling the joints in brick, granite block, and similar pavements of that type. While the old-style pitch filler was easy to handle and did a good job in waterproofing the joints, it did not possess all of the qualities necessary for an entirely satisfactory filler in every case. The production of a mastic filler by mixing sand and pitch on the job produced a better filler but was objectionable for construction reasons.

The Barrett Company has conducted research work for several years in an endeavor to discover a coal tar pitch filler which would be as satisfactory as the mastic filler, and still not require mixing on the job and not contain inert material which would settle to the bottom of the kettles during heating. As a result of this work, a new coal tar pitch filler has been developed. The pitch is produced by an entirely new manufacturing process and has qualities which are quite different from those of coal tar pitches used in the past.

Many experimental installations have been made and have been under observation under varying weather and seasonal conditions.

One of the most comprehensive experiments ever undertaken to observe the qualities of various paving brick fillers was conducted by the Ohio State Highway on route 31 in Hocking County, Ohio, in November, 1935. Twenty-one different fillers were used in the construction of a new brick highway. The new coal tar pitch was No. 16 of this experiment, and has been selected as one of the best of the fillers used.

The filler was shipped to the job in steel drums. It was heated to a temperature of 350° F. for application. The filler was poured over the brick from a hand pouring pot, the surface of the wire-cut brick having first been sprayed with a calcium chloride solution to facilitate the removal of the excess pitch from the surface of the brick. The excess was removed without difficulty by the use of hand scrapers, leaving the top of the brick clean and the joints well filled. The scrapers should be kept sharp and operated so as to cut off the filler at the top of the joint and not pull the filler out of the joint. In some cases the scrapers have been heated but best results seem to be obtained by the use of a cold, sharp scraper. Wetting the scraper with water helps materially in keeping the filler from sticking to the scraper. The excess pitch was returned to the kettle and re-melted.

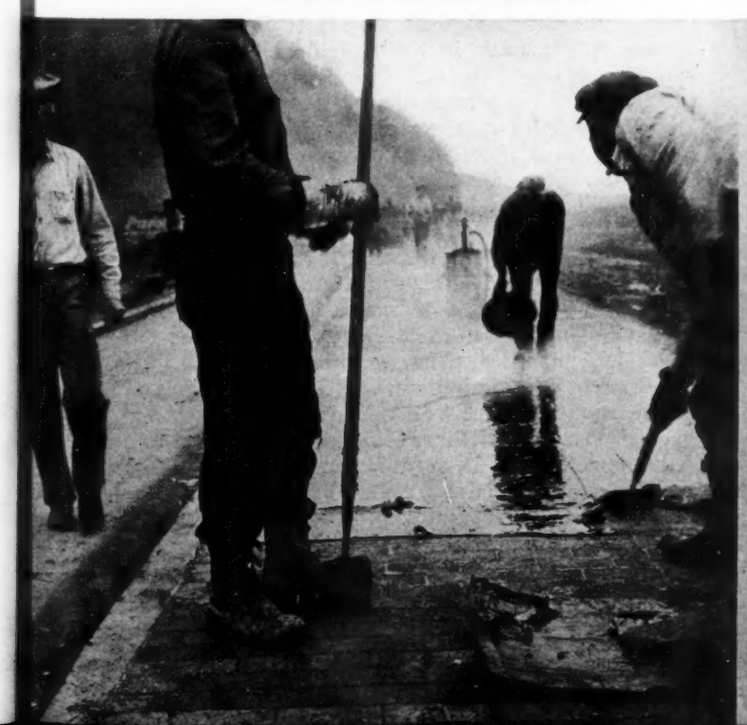
Many inspections of the test section have been made during the past year. The joints have remained well filled and thoroughly waterproofed. The filler has adhered to the sides of the brick. It has not been excessively brittle in cold weather and did not become soft and shift out of place in hot weather. The pitch filler

SPECIFICATION FOR IMPROVED PITCH BLOCK FILLER

The filler shall be a coal tar pitch conforming to the following requirements:

Softening Point, Ring and Ball, degrees C	60 to 75
Penetration, 0°C., 200 grams. 60 seconds	Not less than 12
Penetration, 25°C., 100 grams. 5 seconds	35 to 65
Penetration, 46.1°C., 50 grams. 5 seconds	Not more than 200
Insoluble in Carbon Disulphide, percent	Not less than 20
Specific Gravity, 25°C/25°C	Not less than 1.18

Removing surplus pitch from brick.



Completed brick pavement with pitch filler.

Applying pitch filler to granite block pavement.

has not extruded above the top of the joint and the tops of the bricks are still clean and free from pitch.

As a result of this experimental work, the Ohio State Highway Department has adopted the specification for this new variety of pitch filler given on page 13.

The new coal tar pitch filler retains all the good qualities of the old style pitch and in addition is much less susceptible to extremes of temperature.

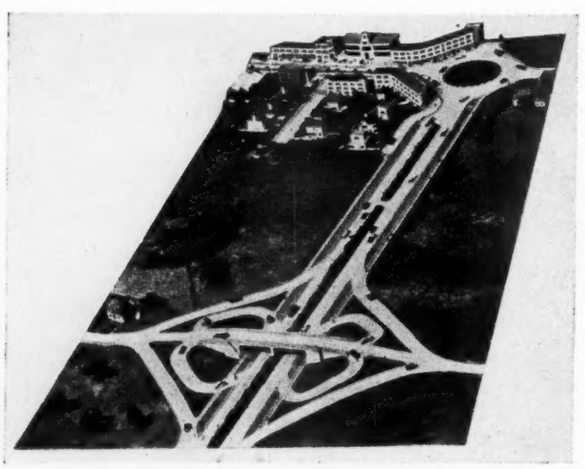
Polychrome Roads

To illustrate the many ways in which coloured concrete can be used as a safety factor on modern highways, the Cement Marketing Company, Limited, are exhibiting at various centres throughout the country a detailed model which incorporates many features that merit the attention of those concerned with road safety.

The model has been so designed as to include a main highway with dual carriageways, a secondary road with a fly-over, and a traffic roundabout leading into a road serving a typical built-up area.

The segregation of traffic on the highway is by means of coloured areas planned as follows:—

On the extreme sides of the road are footpaths in buff concrete, separated from a cyclists' track in red by a green concrete verge with yellow concrete kerbs; the track is similarly separated from the carriageway. The latter is shown in 20-ft. widths on either side of an island, on which there are bushes to screen the lights of traffic going in different directions. Each 20 ft. is shown in 10-ft. lanes, that near the kerb for slow traffic being ordinary gray concrete, and that near the island for fast or overtaking traffic being of buff concrete.



Model illustrating use of colored concrete in highway construction.

The fly-over is shown as a 20-ft. carriageway with a single pedestrian track in buff. Access to the highway is by means of steps leading down on either side.

The roundabout is shown as being kerbed with alternate yellow and black concrete kerbs, and all pedestrian crossings are lines of bright yellow concrete laid between the regulation studs.

The town road is shown as a 30-ft. carriageway, the centre 10 ft. being in red and flanked by grey concrete, while on either side, and separated by islands, are service roads for the shops and flats.

The scheme is far from being visionary. It is practical in every detail, and already a number of schemes have been carried out in coloured concrete incorporating one or more of the items.—*The Surveyor.*

Illinois Low-Cost Road Program

ON January 1, 1936, the Illinois Division of Highways, as a part of its program for the construction of low cost secondary roads, had completed a total of 309.65 miles of stabilized gravel and crushed stone surfaces. An additional 55.71 miles was placed under contract for construction during 1936, this mileage being confined largely to locations where materials can be obtained locally. Of the mileage built prior to January 1, 1936, 15.65 miles were further improved with a bituminous surface of some sort and the 1936 program includes the placing of 86.77 miles of bituminous surfaces on stabilized bases.

A soils laboratory has been established by the Bureau of Materials in Springfield and branch laboratories equipped to make routine tests have been established in the several district headquarters. These laboratories will not only perform work connected with the construction of stabilized surfaces but also general soils work, such as the treatment of subgrades, analysis of embankment materials, and the study of drainage problems.

A series of bulletins on soils and drainage work are being issued by the Bureau of Materials for the field engineers engaged in this work.

The bulletins issued to date cover the following subjects: 1. Announcement and outline of subjects to be discussed in ensuing bulletins. 2. Correction tables for the hydrometer analysis. 3. Soil, soil forming processes, geological classifications, soil materials, chemical composition, color of soils, organic matter of soils. 4. Texture, mechanical analysis, textural grouping. 5. Characterstics of soil separates. 6. Classifications of field tests, classification chart. 7. Structure, structural classification, granulation, structural terms. 8. Specific gravity and actual weight of soils.

Rehabilitating a Large Sewer of Inadequate Strength

By Joseph P. Reinheimer, Assoc. M. Am. Soc. C. E.* and Harold E. Senf, Assoc. M. Am. Soc. C. E.**

MILL Run interceptor is the largest storm sewer in Springfield, Ohio. It drains the high level district or about half the city and has a combined urban and suburban drainage area of 5000 acres. Originally an open stream with culverts under streets and railroads only, it has gradually been enclosed through the heart of the city for a distance of about a mile from its outlet into Buck Creek.

In view of this piecemeal construction policy, it is not surprising that the sewer embodies various materials and different design principles. The older portions, in general of stone arch construction, vary in rise and span to fit the local topography. Newer sections are chiefly of reinforced concrete and rectangular in shape. The first intimation the city had that any portion of the sewer was in bad condition was when a section collapsed under an automobile storage garage dropping eleven automobiles into the opening.

At this point the sewer was of rectangular reinforced concrete construction having a width of twenty feet and a height of about eight feet. Collapse was complete for a distance of only forty feet, but investigations revealed bad barrel cracks and pronounced deflection on both sides of the break. Complete rehabilitation was deemed necessary for the sewer under the entire automobile storage building or a distance of about 105 feet.

After several plans for utilizing existing portions of the structure had been discarded as impracticable it was decided to build a corrugated multi-plate arch inside the old structure for the entire length of 105 feet. The arch selected for the purpose was of 18-foot span, 5′ 2½″ rise, having a periphery of 5½ plates of No. 1 gauge metal, and set on concrete footings high enough to provide the maximum headroom possible inside the old structure. The resulting reduction in waterway was not objectionable, since the favorable grade (2.95%) at this point, even with the reduced area, will develop a capacity in excess of that afforded by adjoining sections of stone arch barrel.

The first step after propping the damaged portion of the sewer and shoring the building overhead was the construction of the footings. These were constructed one at a time of 1:2:4 transit-mixed concrete with a 2″ by 2″ groove in the top of each to receive the corrugated plates. Flow in the sewer, of an average minimum depth of six inches, was temporarily diverted to one side, during construction on the other, by means of a sand-bag cofferdam.

Erection of plates followed immediately after the curing of the footing concrete. No unusual difficulty was encountered in this work although progress was slow because of the necessity for supporting the old structure. Bents of 8″ by 8″ pine supporting the old roof were removed progressively ahead of the plates and reinstalled inside the arch; a wooden block being wedged between the arch and the old roof at each strut to transfer support to the roof pending placement of the backfill. For a length of about ten feet where deflection in the roof slab was greatest it was necessary to trim the slab to provide clearance for the arch. A pneumatic pavement breaker suspended from a sling was used.

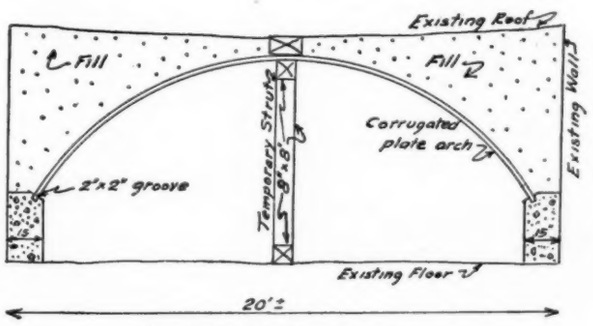
Backfill between the old structure and arch consisted of very dry 1:9 transit-mixed concrete. This concrete compacted very well and completely filled the opening, although of negligible structural value. It was chuted as near to final location as possible, then shoveled into position and consolidated by hand tamping.

When the plate arch had been installed, backfill placed as described, and bents removed, the city's responsibility ended. Earth backfill over the open portion of the arch was provided by the building owner, who also restored ruptured underground piping and concrete floor and made minor repairs to the building. Because of the inability to use a large force of men effectively in the constricted quarters, the city's portion of the job took about a month, but at no time was the flow interrupted in the sewer.

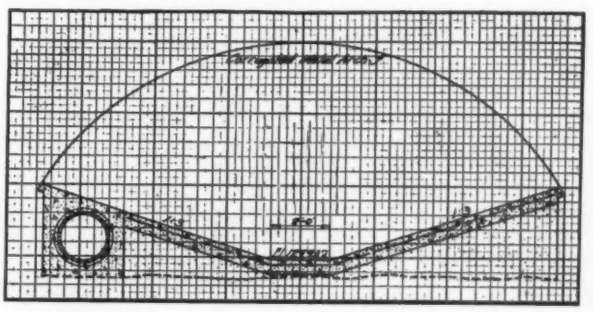
In order to bring the sewer to a more uniform floor and bottom section throughout, it is proposed in the near future to build up the floor with a level invert 2 feet wide, flanked by a 1:3 slope on each side, to be of concrete 6 inches thick. At one side under this slope there is to be an 18-inch clearwater conduit of tile.

Plans for relining the sewer were prepared by John W. Story, Jun. Am. Soc. C. E., assistant engineer for the city, at the direction of Wilbur H. Story, city manager, and William E. Lucas, director of public works. Work was performed by city maintenance forces under Dan Hollingsworth, foreman, and supervised by Joseph P. Reinheimer and Ben Gordon of the City Engineering Department.

*Assistant City Engineer, Springfield, Ohio.
**Field Engineer, The Ohio Corrugated Culvert Co., Middletown, Ohio.



Typical section through sewer.



Proposed reconstruction of floor, with clear-water conduit.

Top of spillway before work began, with wall of embankment in the background.

Two sections of the dam completed, shows rails driven into old spillway, and cofferdam.

Creston Doubles Capacity of Its Reservoir

By ARTHUR K. OLSEN

Superintendent and Engineer, Creston City Water Works

IN June, 1934, during an extremely hot, dry spell which had been preceded by a year or two of less than normal rain fall, the water supply of Creston, Iowa, which was derived from a 300 million gallon reservoir, was completely exhausted. For the next six months water was shipped in from Council Bluffs, 100 miles west of Creston, until December rains partially filled the reservoir.

It apparently required such a catastrophe to rouse the citizens to an action the necessity for which had been apparent years before. The water had been supplied by a private company which was not able to secure a franchise and, without one, naturally did not wish to go to the considerable expense of increasing the supply, although warnings of impending shortage were given in 1930, when the reservoir for a time was dangerously low. The company was blamed for the exhaustion of the supply and it would have been impossible for it to obtain a franchise while feeling against it was so bitter, and city ownership seemed to be the only solution. A proposition to buy the plant was voted down by those who wanted to build an entirely new one, but after a 6-week educational campaign in which it was shown that a new plant would cost four times the purchase price of the existing one, which price was fair and reasonable, the purchase was authorized in a second election. Bonds were sold immediately, the plant purchased and work started. The author, who had not been connected with the old company in any capacity, was made superintendent and engineer, but all the other qualified and efficient employees were retained.

The Existing Conditions

Many improvements to the system were needed, but the first was adequate reservoir capacity. The drainage area above the reservoir comprised 18 sq. m. of rolling agricultural land with a run-off in normal years of approximately 1,800 million gallons. As the city consumes an average of about 300 million gallons a year, the problem was simply one of insuring sufficient storage.

Arthur K. Olsen

About 75 percent of the drainage area is farmed and 25 percent in pasture, and therefore silt accumulation had to be considered. It was estimated that approximately 25 percent of the capacity of the existing reservoir had been lost during its 40 years of service due to silt deposits.

With these basic factors in mind, together with the finances available, it was decided to double the present reservoir capacity, which necessitated raising the spillway elevation 3 ft. 4 in. and the purchase of 100 acres of land which would be flooded by the backing of the additional water impounded.

The reservoir at the time of purchase covered 220 acres. The dam was earth fill, 1300 ft. long and 25 ft. high at the deepest part. The concrete spillway, located in approximately the center of the dam, was 244.1 ft. long, 30 ft. across the top, with a 2:1 back-slope 28 ft. long, paved with concrete in two 6-in. slabs, the upper one reinforced; with a masonry headwall at each end. It had proven to be of sufficient capacity to handle flood conditions and therefore needed no alterations in this respect.

The earth portion of the dam had a 2:1 rip-rapped face on the water side and a 1½:1 slope on the land side. It had never shown any leakage or seepage, so it was considered entirely feasible to increase its height. No reliable information could be obtained as to whether a core of any kind had been placed in the dam, except that there possibly was a rock core under the spillway section. It was assumed, however, that there was no core of any kind.

Design of the New Construction

The spillway addition is practically a low dam on the top of the original wide spillway and its design involved only the usual factors in dam design, such as resistance to overturning, shear, sliding, etc. The direct water pressure was negligible, and that which would be exerted by the ice freezing on the reservoir when at the elevation of the spillway crest was used

as the basis of design. (During the past winter the reservoir was almost full when it froze to a depth of 30 inches, thus giving a most extreme test to the spillway).

Safety from overturning was easily provided. That against slippage of the new section on the smooth, level surface of the old spillway was not so simple. Roughening the surface and designing the new section with sufficient weight to resist sliding would require a large addition to the volume of concrete, and moreover it did not seem wise to rely on this alone. Instead, it occurred to me to drive H-beams through the spillway paving into the earth beneath, allowing them to project 3 ft. above the spillway surface, thus doweling the new sections into the dam, and the design provided for a double row of such beams staggered and at 5 ft. centers across the entire length of the spillway. (It happened to be possible to obtain 85 lb. rails 33 ft. long, which had been taken up by the C. B. & Q. R. R. Co., at a price considerably less than new H-beams, and these rails were used.) This permitted reducing by almost a third the amount of concrete needed and at the same time giving a greater factor of safety.

The water side was given a slope of 1¾ to 1 to allow the ice to slide upward rather than exert its full pressure; this slope beginning at the water edge of the old spillway. The crest was made 3 ft. 5 in. wide, and the down-stream face was curved to minimize the scouring effect of the overflow in striking the old spillway surface. (It is proposed to protect this surface ultimately with a 6-in. slab of new concrete.) The total width of this addition at the base is 16 ft. Water-tight expansion joints were placed every 40 ft. (which is about a day's pour for the single-sack mixer used), thus eliminating construction joints.

This structure was reinforced longitudinally with three lines of 1 in. round bars, two attached to the up-stream dowel beam and one to the down-stream; and transversely with ⅝ in. round bars at 2 ft. centers placed parallel to and 4 in. from the surface of the concrete. The material used was one hundred 85 lb. rails, 278 cu. yd. of concrete and 7,000 lb. of reinforcing steel.

The headwalls at the ends of the spillway were raised to retain the additional embankment, the extension consisting of a concrete retaining wall 2 ft. wide at the base and 6 in. at the top, dowelled into the old wall and thoroughly reinforced and of sufficient height to allow 5 ft. freeboard, which is 1 ft. 6 in. more than the old dam had. They were continued with a 6 in. facing extending over the face of the old masonry down to the old spillway.

Designing the earth section presented no particular problems. It was raised 5 ft. above the former elevation, with a 2:1 slope on the water side and 1½:1 on the land side and given a 10 ft. crest, the base being widened accordingly. No core was considered necessary as the old dam had none, and a very fine bank of yellow clay was available at one end of the dam for making impervious embankment. The addition required 7,000 cu. yd. of this material, principally because the base had to be widened.

Construction

As soon as the weather permitted, construction began with two crews, one on the earth portion and one on the spillway. The entire project was set up as a work relief one, the Federal government paying the laborers and the city furnishing all supervision, equipment and material. On account of the abundance of laborers, earth was loaded into dump trucks by hand. By using crews of 50 to 75 men per shift, it was possible to keep earth work progressing at the same rate as that on the spillway.

Before any earth was placed on the existing dam, the entire crest and bank slope was cleared of sod, and longitudinal trenches 1 ft. wide and 2 ft. deep were dug at 4 ft. centers on the backslope from one end of the dam to the other, to insure bonding of the new embankment to the old. The fill was carried up from the toe in 6 in. layers, the 2-yard dump trucks used being so routed over the fill as to pack it thoroughly. The water side was carried up on a 2:1 slope and riprapped heavily as soon as compacted. The back slope was immediately sown to blue grass.

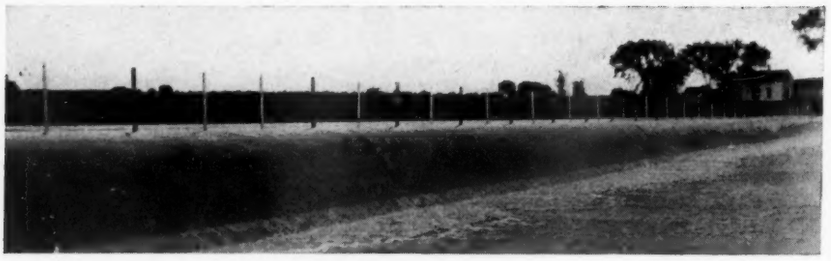
In constructing the spillway addition the first step was driving the rails. Holes for them were cut through the concrete spillway slabs with star drills and sledges. The rails were driven with a land pile driver using an 1800 lb. gravity drop hammer. A crew of 3 men easily drove 10 rails in 8 hours.

As soon as sufficient rails for the first section had been driven, a coffer-dam was built at the edge of the spillway from the head-wall to the first expansion joint, using fir sheathing and sand bags. This was necessary because the water stood at spillway level and it was desired to extend the slope of the new concrete down to a vertical cut-off wall about 6-ft. deep along the edge of the spillway slab, the top of which wall was about 1 ft. below the water level. A header board of 2 in. plank built to fit the cross-section of the dam was set up at the end of the section, and two 1 in. angle-iron screeds similarly shaped were set up so as to divide the section into three equal lengths. After the concrete had been deposited and roughly shaped, a 2 x 6 in. straight-edge was used to strike it off to true form by sliding it over the two screeds and the header board. As soon as this had been done the screeds were removed and set up for the next section and the surface of the concrete finished. The concrete was made as dry as it could be handled to minimize the slump, the mix being 1:4. The length of the sections was such that a one-bag mixer could complete it in a day.

The day after a section was run, the header board was removed and set up at the end of the next section and the process repeated. One-inch composition expan-

Building up the earth section. Shows how well dual-tired trucks rolled the embankment.

Completed dam face after riprap had been placed.



The completed spillway overflowing, showing the new dam on the old spillway top. Vertical posts on crest for fish net. Toe of addition left with vertical drop of 6" to allow for adding a 6" wearing coat to the old spillway surface.

sion joint material was placed on the face of the finished cross-section, and metal tubes were placed over the ends of the longitudinal reinforcing bars, which extended 12 in. into the next section. Vertical copper bellows strips were placed at each joint to prevent leakage.

Fortunately rain did not cause the reservoir to overflow at any time during construction; but when the next to the last section was being poured a gale sweeping across the reservoir raised waves which, when they struck the spillway, rose to a height of 10 to 15 feet. A portion of the section which had not yet set up was washed away in a few minutes but we were able to salvage some of it the next day; the surface being cut away back to the sound concrete and the rest of the section poured as usual. The last two sections were made with high-early-strength cement to provide for a possible rise of the reservoir level.

The concrete headwalls were poured in the same manner as any concrete retaining wall, with a 6 in. facing extending over the face of the old masonry portion down to the old spillway elevation.

This completed the first and most important step in the improvement program undertaken by the city. The cost of the entire improvement was $13,114.40, exclusive of Federal funds. Since then many other needed improvements have been made in order to entirely recondition the plant and distribution system, the work having been made possible by utilizing WPA funds.

Applying Activated Carbon in Reservoirs

For removing odors and tastes in reservoir water, usually caused by algæ, where the water is not filtered, activated carbon has been used successfully in a number of cases, including Bath, England (believed to be the first to do so), Belmont Lake, Washington and Tyrone, Pa., New Haven, Conn., and Kittery Junction, Me.

In discussing the experiences of these cities, E. A. Sigworth, of the Industrial Chemical Sales Co., says that the most serious drawback to a ready acceptance of this method of application is the danger of carbon getting into the distribution system. But the amount used averages only about 2 ppm, while 8 ppm is barely perceptible in a glass of water; and carbon is not at all harmful if taken internally. It is, of course, desirable, however, that as much as possible of the carbon settle in the reservoir.

It has been found that activated carbon settles much more rapidly in a large body of water than in a glass. But its structure makes it very buoyant, and it should not be spread in dry form on the surface of the reservoir, but should first be wet thoroughly.

The common procedure is to take a barrel, drum, or other suitable container, fill it over half full of water, and then add the activated carbon at intervals with stirring until a thin slurry is obtained, and no carbon is floating. This slurry is then applied to the surface of the reservoir. The distribution of the carbon over the surface should be proportional to the depth of water. The carbon slurry should be spread as uniformly as possible and for this purpose the most satisfactory method would be to utilize a spray under pressure. However, this is an unwieldly method in most cases. A very good distribution can be obtained, if a motor boat is available, by applying the slurry of activated carbon as close to the propeller blades as possible. In the case of an outboard motor, best distribution can be obtained by applying the carbon just ahead of the propeller blades.

The amount of carbon necessary is, of course, dependent upon the intensity of the tastes and odors and the size of the body of water to be treated. With an average condition, 2 parts per million or about 16 lbs. per million gallons is usually found to be sufficient. Larger proportions have been used, but for the most part those used have varied between 10 and 20 lbs. per million gallons.

New Hydraulic Laboratory of University of Minnesota

The University of Minnesota (aided by funds from the WPA) is constructing a large-scale hydraulic laboratory on Hennepin Island, in the Mississippi river at St. Anthony Falls and in the milling center of Minneapolis. The power dam makes available at all times a head of 48 ft. for laboratory purposes.

The laboratory is designed to handle flows of more than 300 cfs. Below the buildings are two basins for measuring the discharge, supplied with pneumatically-operated cylinder valves. One section is provided for testing turbines and other hydraulic machinery. The main experimental room is approximately 300 ft. long and 45 ft. wide. An overhead flume 8 ft. wide and 9 ft. deep, connected directly with the river above the falls, is provided with numerous offtakes to supply water for various experimental projects. Two other channels at a lower level extend the full length of the building, one serving as a wasteway; the other, 9 ft. wide and 6 ft. deep, supplied directly from the river, is arranged for a wide variety of experiments. A towing car will pull current meters, model ships, etc., through the flume. Experiments can be made on model rivers and other problems of flow in open channels.

Another building will contain the hydraulic machinery laboratory and offices. The main floor will provide an unobstructed space 34 ft. wide and 125 ft. long, provided with an overhead crane. At one end of this building is a large turbine-testing pit extending to a depth of 25 ft. below the main floor, with a tailrace at the level of the lower pool of the river.

The laboratory will be used for graduate study and for many types of research projects, many of them in cooperation with federal, state and commercial interests. Large-scale studies will be made of spillways with crest gates as soon as the laboratory is completed, and much of the work on sediment transportation by rivers that is now being carried on at the University's existing laboratory will be transferred to this one.

The Editor's Page

The American Road Builders' Association

Year in and year out, through good times and poor, the ARBA functions for the roadbuilder, and the most important of these functions is the annual convention. At these, papers and discussions cover a wide range of important topics, and there is always the "show." True, this year it will not be a show in the broad sense, but models, illustrations and other displays will help to bring the engineer, the contractor and the highway non-technical official into closer acquaintance with the progress of the past year.

Nearly a thousand firms are engaged in the manufacture of highway equipment. Unfortunately only a fraction of this number will be represented at the New Orleans meeting, but in general those that are there will account for 75 to 80 per cent of the industry, so far as volume goes.

Progress in road-building equipment has been remarkable during the past year or two. Every person engaged in road construction, or responsible for the administration of it, ought to see for himself each year what has taken place, so swift has been the development in certain lines, so rapid the changes.

As to the programs and papers, these have been prepared to care for the problems and meet the needs of the three major groups that go to make up membership in the Association—the engineers and technical officials, the non-technical and administrative officials, and the contractors.

"See you at the Road Show."

Reducing Highway Accidents

Many remedies have been suggested to reduce the heavy mortality from accidents on the highways. Most of them are fine, or contain some fine ideas. But it seems to us that there has been too little attention paid to the most basic and common-sense idea of all; and perhaps the simplest. That is to build more roads—almost enough of them to take care of our highway traffic.

Perhaps the research men will tell us that density of traffic is not an important factor in accident rate; perhaps that is true, though we do not recall ever seeing any figures to show this to be the case. But it would seem to be only common-sense to suggest that the accident rate will increase with, but much faster than, the number of cars on the road. If a road that can carry 2,000 cars a day with safety is called on to carry three times that number, there will certainly be more than three times as many accidents.

Outside the restricted and built-up limits of the cities there should be plenty of roads to care for all of the traffic. They do not have to be all 4-lane express drives; plenty of us prefer to drive on other kinds of roads. Instead of one big express highway running from one city to another, or from the city to the seashore, it would be good and safe engineering to provide a half dozen roads that, with a relatively small loss of time, should carry the motorist where he wants to go.

We believe that there are many places where to do this would not require much new construction. The utilization, by widening and surfacing, of a number of existing unimproved roads would do the trick. And we bet it would go a long way toward reducing that highway accident toll that we hear so much about. Also it would greatly please the many automobilists who would like to keep away from the speed maniacs; and would benefit those who are compelled to use these roads, whether improved or not.

The Road Building Industry

There are 2,116 highway contractors who, in 1935, did more than $500 worth of work. And they did $280,332,000 worth of work in that year. These are the figures just reported by the Bureau of the Census, collected by 34,000 enumerators who investigated the entire contracting field.

The number given includes those who built "roads, streets, alleys, sidewalks, guard rails and fences, parkways, parking areas, airports, bridle paths, athletic fields, highway bridges, grade separations involving highways, and light construction sewage and water works improvements." It is believed that no contractor who had a regular place of business was overlooked, and not many of the small ones whose office was "in their hats." This would seem to make rather foolish the claims of some that there are 10,000 road contractors in the country.

The amount of work reported was only contract work; work done by road officials by day labor is believed to have totaled two or three times this amount.

Progress in the Water Works Field

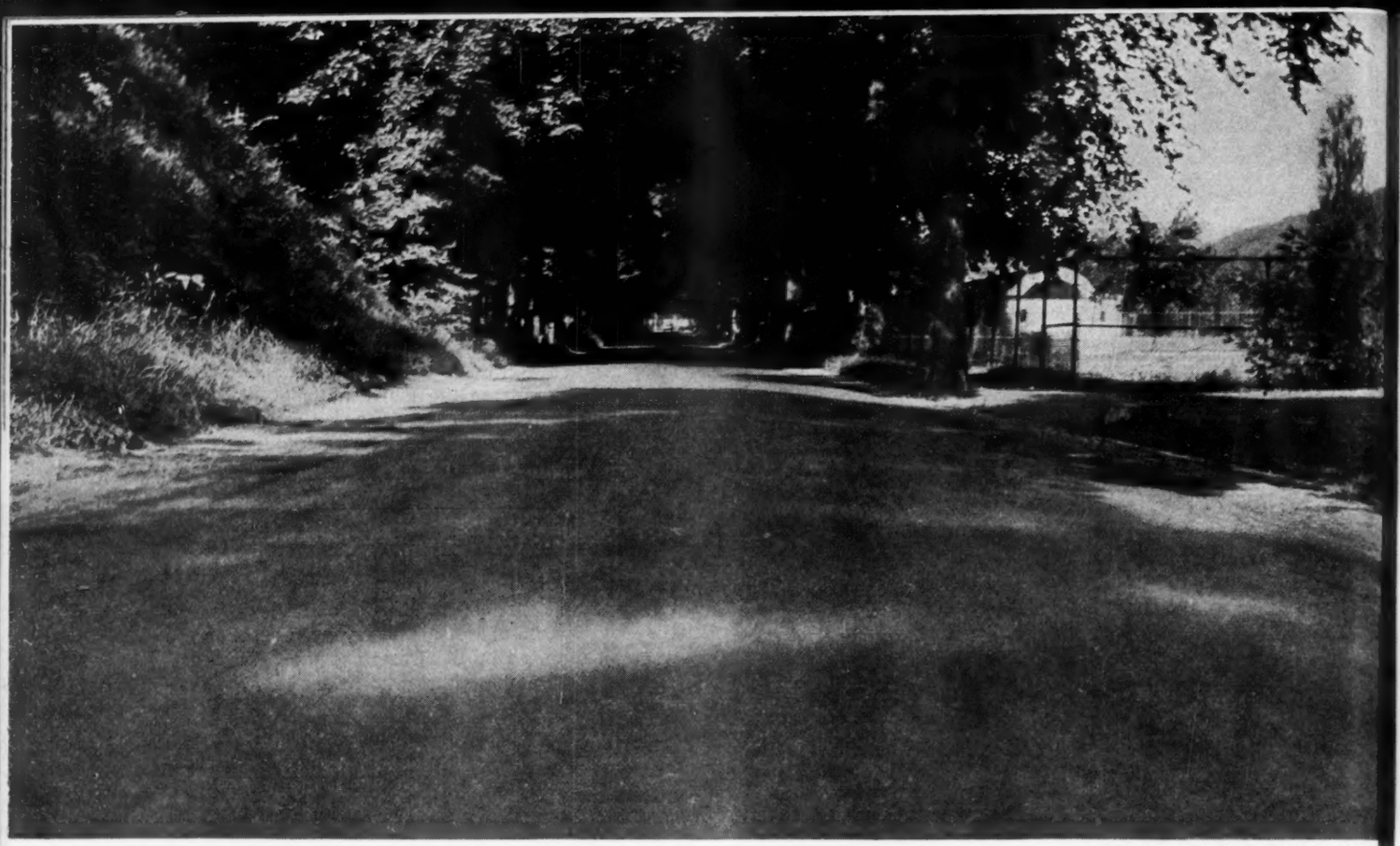
Many problems are facing the the American Water Works Association and its new secretary, Harry Jordan. Perhaps no man could be found better fitted to cope with these problems, but that fact does not make them easier of solution.

It is sometimes stated that there are ten thousand water works plants in the country. This takes account of everything, including summer camp supplies, etc. As a matter of fact, there are only 1,833 cities of more than 5,000 population. Therefore, assuming the ten thousand, 8,167 of these plants serve very small communities, the waterworks superintendent of which is very likely to have comparatively little technical training.

In extending its membership in this group, and holding it the Association will have to provide some services, instructional or otherwise; and these will have to be pitched mainly on a plane of everyday work. Long and highly technical discussions will be of doubtful value to such members. It is in serving this large class of men and keeping them interested in the association that the chief difficulty lies.

Index for the 1936 Volume of Public Works

Any subscriber who wishes a copy of the Index of PUBLIC WORKS for the year 1936 can obtain one by sending a request to the publishers.



Courtesy Standard Oil Co. of Ind

How to Build Low-Cost Bituminous Roads

Public Works presents herewith a resume of good construction methods for the principal types of low cost roads, and a summary, as well, of recent important developments in equipment and procedure. Construction of such roads is of paramount importance not only to the many thousand counties and cities, but to the states, also; to the engineers, superintendents, and construction men serving these governmental units, this article is dedicated. Further specific information is available on request.

Surface Treatments

"Surface Treatment" is a term broadly employed to describe the methods of applying bituminous materials to a roadway for the purpose of hardening, smoothing and waterproofing the surface. A rather confusing terminology has grown up on the subject, using such terms as road oiling, mat coat, carpet coat, double surface treatment, etc., and the recent development of thin road-mix tops, with an added list of names, has contributed still further to this confusion. In general, surface treatments are so called when the resulting thickness of wearing course is less than one inch, and where the purpose is to waterproof and provide resistance to abrasion and wear.

The kinds of surfaces to be treated will be either loose or bonded. In the first classification are cinders, gravel and traffic-bound macadam. In the latter are chert, shale, clay-gravel, stabilized, waterbound macadam and others.

An important condition before treatment is uniformity of the surface material. This means that every square yard shall be of the same quality and character as every other square yard. Pot-holing of a surfacing occurs almost invariably because of lack of uniformity, there being coarse material in one place and fine material in another adjacent to it. The bituminous material in the treatment penetrates one area differently than another; then one area settles a little more than the other; then under traffic there develops uneven wear and deterioration in spots. This difficulty can be almost entirely prevented by scarifying and blading until all areas are as nearly alike as possible. Even for such surfaces as waterbound macadam, it is better to scarify the entire surface to a depth below the deepest pot-hole than it is to endeavor to patch the holes to the general level of the adjoining surface. The coarse and fine particles should be thoroughly mixed and the texture of the surface made uniform by breaking up the lumps, after which, by continued blading and dragging, uniform consolidation is obtained. It is not so much the rising or falling of the entire roadway under conditions of frost and water which causes a break-up in the surface, as the differential rising and falling of small areas of the surface.

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Treatment of Loose Surfaces

In the spring the surface should be carefully bladed to obtain as great a degree of consolidation as possible under the floating cover, with particular regard to the uniform distribution of all

sizes of the aggregate particles so that coarse particles are not in spots. After such surface conditioning, this cover should be partially swept from the surface, but not so completely as to disturb the firm underlying material.

The first application consists of a low viscosity bituminous material, applied at the rate of ¼ to ½ gallon per square yard. This priming operation is the most important part of the entire treatment operation, as it is essential that all loose material be coated and cemented together. The bituminous material must have a low viscosity in order to penetrate rapidly and to coat the dust particles, and yet must harden as soon as the full necessary penetration has been obtained. Both tar and asphalt products have been developed for this purpose, and are used interchangeably as desired. As a general thing, no cover coat is placed over this priming application, as it is desirable to have it completely absorbed. There are instances, however, where a light application of cover may be desirable. In such cases the cover coat would consist of the material which previously was swept to the roadside. As soon as the cover is applied, the surface is dragged with a broom-drag, insuring a complete coating of the cover and also tending to fill up any corrugrations which may exist in the surface. Loose surfaces are particularly liable to this condition. Traffic is permitted to use this primed surface for several days. Any defects showing under traffic can be repaired easily by the application of additional primer and covering with the same surface aggregate until a smooth, even surface appears which is uniform and thoroughly consolidated.

The seal coat has an entirely different purpose and function; it is not intended to penetrate the surface except to such minor extent as will insure a perfect bond with the bituminous coated aggregate already in place. Consequently a more viscous material is employed, and is applied at the rate of approximately ¼ to 1/3 gallon per square yard.

Immediately after the second application of bituminous material the cover coat is applied at the rate of 25 to 30 pounds per square yard, preferably by the use of a mechanical spreader, as results are better than by the most careful hand spreading, and the roller should be operated once over the surface. This sets the bottom fragments of the aggregate firmly into the bituminous material. The broom drag should then be used to manipulate surplus cover coat from one point to another, in such a manner that a uniform smooth surface is obtained. The rolling and broom-dragging should then be continued simultaneously until the final set occurs. By following such a procedure a uniform texture of surface will be obtained, a minimum whip-off of the cover coat will occur and there will be no bleeding or irregularities of any kind in the work. Attention to these small details will make all the difference between just an ordinary surface treatment and one which will be of enduring character and complete smoothness.

An Etnyre distributor mounted on a Fruehauf semi-trailer, owned and operated by Arrow Petroleum Co., Forest Park, Ill. Tank capacity 1000 gallons; insulated; equipped with heating apparatus, extra motor, thermometer and tachometer. Mounted on International tractor-truck.

All-Purpose Spreader shown in action above and at rest below.

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Retreatments

Before retreatment, any breaks in the surface should be carefully repaired. The roadway is then carefully swept well beyond the outside edge of the treatment so that no dust or dirt pockets are present. The bituminous material may be applied either as cold treatment or a hot treatment. Where the road has been thoroughly stabilized, the trend is toward hot treatments because of using a more viscous bituminous material with its ability to hold a heavier application of aggregate. The selection is largely a matter of convenience. With bituminous cements it is necessary to provide for heating. There have been developed small portable units for heating tank cars, using a small gas-fired steam boiler of the condensing type. A series of torches under the boiler pipes develops superheated steam, which circulates through the coils of the tank car and back to the boiler after condensation. These machines are so highly efficient that they will quickly raise the temperature of the bituminous material to any required heat.

The rate of retreatment application is usually from 0.25 to 0.4 gallon per square yard, according to local conditions. If the retreatment is to replace the abrasive wear of traffic and renew the waterproof condition, then the minimum rate of 0.25 gallon per square yard is applied; but if, in addition, it is desired to increase the strength of the surface, the application may be in the larger amount. The cover coat should range in size from ¼ inch to ¾ inch, be free from dust and be applied at the rate of 30 to 50 pounds per square yard, according to the amount of bituminous material applied. This coat should be applied by mechanical spreaders, followed by one

Distributing aggregate cover-coat on a Pennsylvania highway.

passage of the roller and thereafter by simultaneous rolling and broom-dragging until the surface is thoroughly compacted. This procedure gives a waterproof surface, free from any whip-off.

The use of non-curing oils is not recommended for surface treatments on selected aggregates. These materials do not hold such a cover coat in place, resulting in pick-up under traffic and splashing of vehicles. Furthermore, even when they do become apparently dry as a result of absorbing dust and dirt, they frequently bleed and become disagreeable for traffic under high summer road temperatures, and also shove and ridge to make a rough surface. The use of such materials has discredited surface treatment operations in some localities but, if the correct bituminous materials are used in the manner herein described, little trouble of this kind will be experienced.

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Bonded Surfaces

Bonded or tight surfaces consolidate under careful blading or rolling to a homogeneous mass and behave in every way like a hard pavement, except for dusting more or less rapidly under traffic. These do not require as much priming as loose surfaces but, in all other respects, the treatment is similar. The first step is the careful preparation of the surface to obtain a uniform surface condition and a true and even cross-section and profile.

Repeated blading and dragging of the road surface should be carried on during the spring months and all weak places repaired through proper subdrainage and replacement with new material. In the early summer, after the roadbed has been thoroughly "puddled" and set as a result of the blading operations, the surface is swept lightly with a rotary broom to remove all surplus fine material. While it is not necessary to consolidate and harden the bonded surface (for this has already taken place), it is necessary to kill the dust and to penetrate the surface for a depth of approximately ½ inch so that, when the seal coat is later applied, the entire surface treatment becomes integral with the underlying surface material. With a thin film of dust over the surface no real bond is possible with the seal coat, and water creeps under the mat and softens the surface in spots, resulting in early potholing and ravelling.

The same kind of primer is used as for the loose surface, but the amount may be reduced to 0.25 to 0.35 gallon per square yard, depending upon the density and character of the surface itself. No cover coat is placed, as it is desirable to have the entire amount absorbed. Usually the application is made to one-half the roadway width at a time while traffic is being carried on the other half. From 2 to 4 hours is required for complete absorption. The seal coat is applied the next day or as soon thereafter as practicable, as it is not desirable to have this primed surface under traffic any longer than necessary to complete the absorption of the primer treatment.

A broom drag is used in surface treatment work to distribute cover material.

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Seal Coat Application

The seal coat may be either a hot or cold treatment, with the initial treatment usually of cold material and retreatment with a heavier product. The practice varies more according to locality than for any other reason. The southern states prefer hot application as a rule, whereas the middle Atlantic and northern states use the cold materials. One reason probably is to be found in that the southern roads are newer and constructed more accurately to grade, whereas the northern states have a large mileage of stone and gravel surfaces which require smoothing during the surface treatment operations. With cold liquid bituminous products it is possible to drag the cover coat aggregate and correct many irregularities in the surface, while this is not possible with the hot application. Where the surface is true to profile and cross-section, the trend is toward the heavier bituminous materials. There is no necessity for deferring the heavy seal to a later date as in the case of loose surfaces, because a high degree of stability already has been established. Where a soft bituminous cement is applied, the rate of application is about 0.4 gallon per square yard with 40 pounds of cover coat, ranging in size from ¾ inch to 1¾ inches. A second application of approximately 0.2 gallon per square yard, covered with 20 pounds of ¼ inch by ¾ inch crushed aggregate, is then made. In some states this seal coat is accomplished by using the single application of heavy bituminous material, followed by a cover coat of ¼ inch by 1¼ inches. Where the aggregate is thoroughly mixed, good work has been obtained; but where the small sizes have been segregated into pockets, fat and lean spots will show in the completed work. For this reason it is recommended *for an original treatment*, that the seal coat be made in two applications and that the cover coat also be made in two applications using the more closely graded sizes. There is little, if any, additional cost attached to work done in this manner and there is positive assurance that the texture of the finished roadway will be uniform and that the voids in the first treatment will be completely filled by the smaller sized cover coat used in the final sealing operations. Too much emphasis cannot be placed upon these little details.

Where the seal coat on original treatment is done with the lighter bituminous materials the rate of application is from 0.25 to 0.35 gallon per square yard, covered with 25 to 35 pounds of crushed aggregate ranging from ¼ inch to ¾ inch in diameter. The aggregate should be spread by mechanical means, wherever possible, followed by one passage of the roller and then simultaneous rolling and broom-dragging until thoroughly set. When spreading aggregate by mechanical means the application should be ahead of the wheels.

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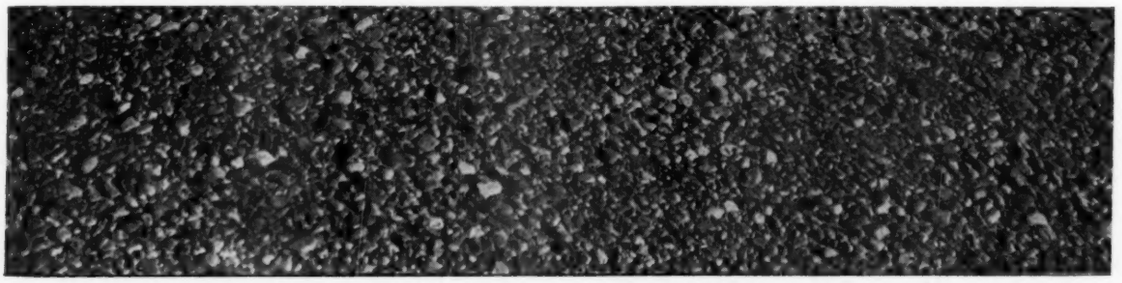

Surface of tar treatment on stabilized gravel.

Aggregates

Reference has been made to the desirability of using properly graded aggregate and emphasis again placed upon the matter in connection with seal coat operations. With any crushed aggregate, even under the most careful crusher operations, a certain amount of dust carries over with each particle. In any mixture of fine crushed material, this dust tends to become segregated with the small particles and, when used for cover coat, produces a patchy appearance after the road surface has had considerable traffic. By eliminating the particles, ⅛ inch and smaller, these dust pockets may be largely prevented. It is for this reason that the size of cover coat is so closely specified and it will pay the user to demand properly graded aggregate. The Joint Technical Committee on Aggregates has recently completed a study on this subject.

It will be noted that there is a generally constant relationship in the pounds of cover coat to gallons of bituminous material. This relationship is quite definite and as a general rule 10 pounds of aggregate, either crushed or ground, are required for each 0.10 gallon of bituminous material. This amount includes a given per cent allowance for "whip-off" under traffic which however seldom occurs when seal coat operations are properly directed, but it is always well to provide a slight surplus of cover so that ample provision is made against bare spots.

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Mechanical Handling and Spreading

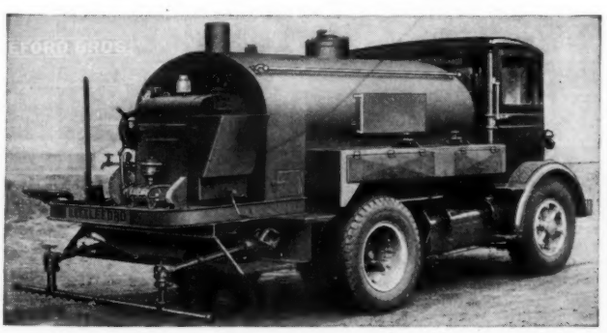
For long haul jobs the motorized distributor often stays on the work and the bituminous material is brought from the railroad tank car by trailer or "booster" tank units. Instead of placing the cover coat along the road in small piles, it is usually delivered at the railroad siding in the total amount required and unloaded from the cars by belt conveyor, either direct to trucks or to the stock-pile, from which it is later transferred to trucks as rapidly as required to keep up with the distributing operations. The aggregate is applied to the roadbed by mechanical spreaders, which not only do the work faster but better than by hand distribution.

The introduction of the grader and the steel broom drag as a means of uniformly manipulating the cover coat after spreading is also a development of recent years, while gasoline rollers have practically displaced steam rollers for purposes of compaction.

This is one of the units of the Shawano Co., Wisc., highway department. It is a FWD truck equipped with a bituminous distributor. The outfit is shown applying road oil to a county highway.

Hauling on pneumatic tires not only is not destructive but may even be helpful in its effect. Trucks on pneumatic tires today, with capacities from 1½ to 3½ tons, move at a speed of 35 miles per hour or more. Not infrequently such truck units cover as much as 200 miles per day on hauls of 30 to 50 miles. In other words, even on these long hauls, three full load trips per day are possible, hauling either ten tons of aggregate or 3,000 gallons of bituminous material. The mobility of modern equipment has had a marked effect on surface treatment procedure. Today a five mile section of road may be prepared, treated and finished so rapidly that one is apt to be surprised, to return the following week and find the entire operation finished.

The kind and amount of surface treatment work to be done governs the amount of equipment. It is desirable to have the work out of the way as early as possible in the spring with a view to having all surface treatment work accomplished in time to leave the roads free and open for the summer traffic. Fall operations, such as light treatments and seal coat work, can be resumed in late September and still leave sufficient time for kneading and ironing out the surface under traffic before cold weather, even in the northern states.



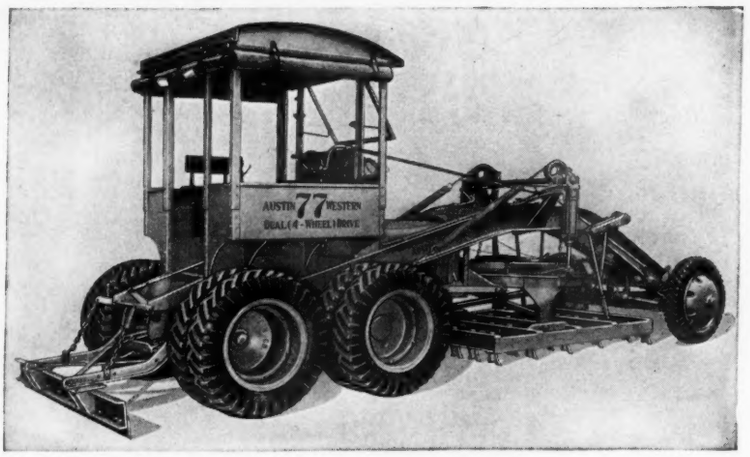
The distributor is the most important unit in the job. This is one of the latest Littleford models.

Tractor grader equipment is standard throughout the country and is all important for road preparation prior to surface treatment. Graders are also used for manipulating the cover coat in the case of treatment of earth road and loose surfaces and, more recently, graders have been used in blading crushed aggregate used for cover coat on heavy treatments.

Emphasis has been placed on sweeping the roadway clean. Present-day design trends toward placing the broom in front of a tractor where the operation is entirely under the eye of the operator and can be carefully controlled. A spare rotary broom should always be on hand and a change made as soon as the old broom becomes worn, as satisfactory sweeping cannot be accomplished with poor equipment. Hand brooms in sufficient numbers also should be on the work to take care of deep depressions and certain places at the edge which cannot be completely swept by the rotary. Wire brooms, bamboo and fibre brooms are all effective, their choice being largely a matter of preference. In addition to the rotary broom, blowers are sometimes used for removing the fine dust difficult to reach by sweeping.

The real heart of the operation, of course, is the distributor. When anything is wrong with it, the entire job shuts down. Consequently the best equipment available should be obtained. The whole function of the distributor is to apply bituminous material to the surface uniformly at a given rate per square yard at a specific temperature and to keep at it day in and day out. There is no reason why a distributor should haul material from the tank car to the job when this work can be done much more cheaply and effectively by the trailer tanks. There are, of course, exceptions to this rule, where the jobs are so small that it would not pay to have the trailer tank equipment available.

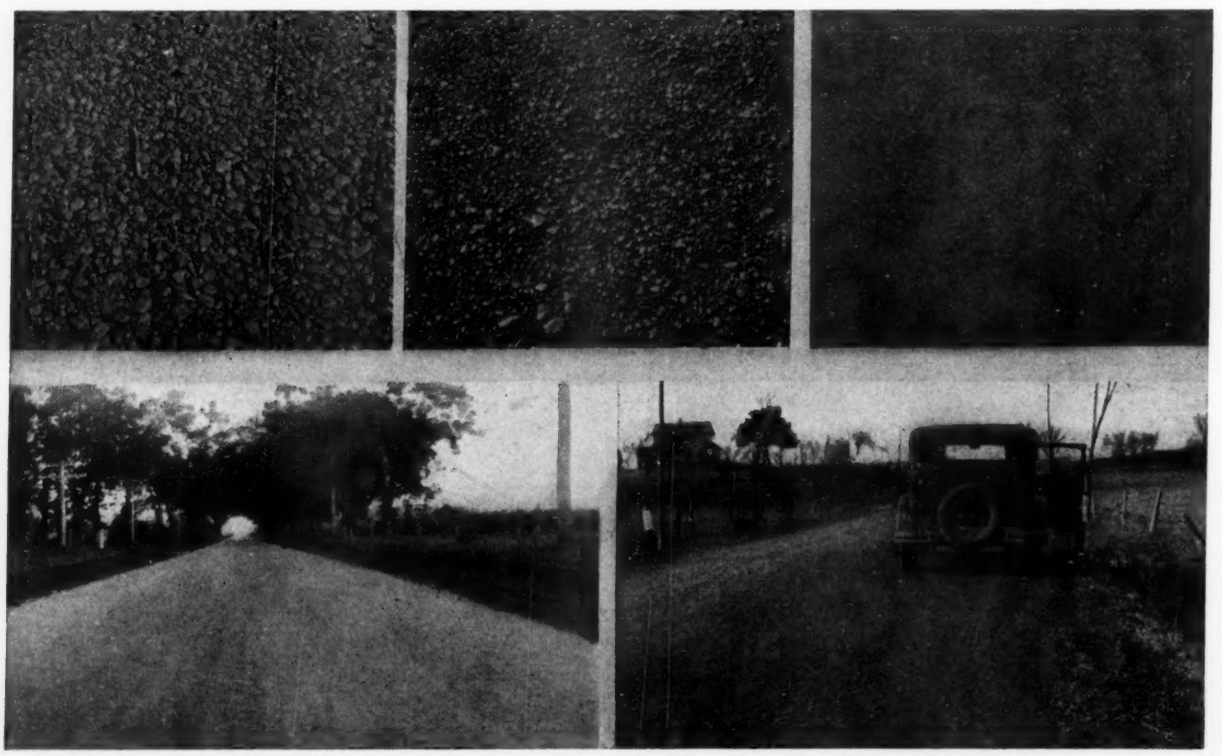
A satisfactory distributor must have a sturdy chassis and power unit, a proper pump to maintain sufficiently high and uniform pressure, a heating and circulatory system to maintain constant temperatures, spray bars and nozzles easily



Typical of special equipment for modern roadbuilding is the Austin-Western "Scarifyer."

and quickly interchangeable for varying roadway widths and different rates of application and, finally, an arrangement of all the component parts so as to be easily accessible for repair and replacement. There are several excellent machines on the market complying with these requirements and today there is little difficulty experienced in their use. Distributor capacities range from 500 to 1200 gallon tanks in the large sizes, with 300 gallon tanks in the miniature type. There is no particular reason for having the sizes above 800 gallon capacity. Their development came about largely through the practice of hauling the bituminous material from the tank car to the job. With the present-day practice of keeping the distributor on the job, a 600-gallon unit will apply almost as much per day as any of the larger sizes. The only difference is the somewhat greater number of transfers from the trailer to the distributor and, as this rarely takes over five or ten minutes, it can be seen that the difference between 600 gallons and 1,000 gallons capacity is relatively small in a day's work. In the midwestern sections, on long jobs, records of 50,000 gallons per day using a 600-gallon distributor have been made. The materials applied were cutbacks and light road oils which required a minimum of heating. An average daily output of 20,000 gallons per day with the lighter products is easily obtainable where the "booster" or trailer truck supply can be carefully timed and coordinated with the other operations. In the East, on widely separated work of relatively short lengths, the average rate of application will vary from 4,000 to 10,000 gallons daily. Where volume is reduced to this figure there is relatively little difference in the amount which may be applied, whether of the lighter products or of bituminous cements which must be heated to 300° or more, as the other delays are more time-consuming than the requirement for the extra heating.

Careful planning of the job in advance of the start of actual operations will be conducive to better work and more rapid completion. Supplies should be accumulated in advance, all cover coat, or at least the larger part, should be actually close to the job in large stockpiles before the first application of bituminous material is given. The capacity of trucks to deliver materials at the required rate should be predetermined, one or two additional ones being available if needed in case of breakdown or other emergency. Having figured the rate at which the equipment can apply the bituminous material and cover coat, arrangements should be made for delivery of tank cars on a regular schedule without delays. There will be days when no work can be done because of bad weather, but it is better to pay a few demurrage bills than to have the job held up because of no tank car deliveries. Spare parts for equipment should be on hand, so that no minor breakdown can tie up the whole operation while the needed spare parts are being sent for. Every machine or piece of equipment has one part that is more apt to fail or wear out than the rest and by anticipating such repairs the investment in spare parts will soon more than be made up by prevention of costly delays.



A tightly sealed tar gravel mulch. **Loose unsealed gravel mulch.**

Above: Unsealed gravel mulch—almost certain to ravel. Center: Poorly graded large size cover. Right: Well sealed tar macadam.

Road Mix Surfaces

Building in Road-Mix in Sheboygan County, Wisc.

Road-Mix is a term used to describe the mechanical mixing of mineral aggregate and bitumen directly on the roadbed or road base as contrasted with premixing in plants. The term *mixed-in-place* is widely used, but other common terms are *retread, oil-mat, turn-over method, oil-process* and *gravel process.* Basically the fundamental principles involved are the same.

In general, *road-mix* refers to a 1-inch or greater completed thickness, requiring approximately 80 pounds of aggregate and 0.8 gallon bituminous material. Road-mix methods recently have been applied to quantities as small as 40 pounds of aggregate, but this discussion will deal with thicknesses of 1 inch or more, since these constitute the great majority of jobs of this type.

There are two distinct types of road-mixes. In the *graded aggregate* type the aggregate consists of a continuously graded gravel or crusher-run stone ranging from about 1-inch diameter down to and including dust. In the *macadam aggregate type* the aggregate is 1½ inches down to ¼ inch diameter, free from dust. The difference in the character of mineral aggregate involves using bituminous products with distinctly different properties for the two types, and the resultant mixtures are unlike in general characteristics.

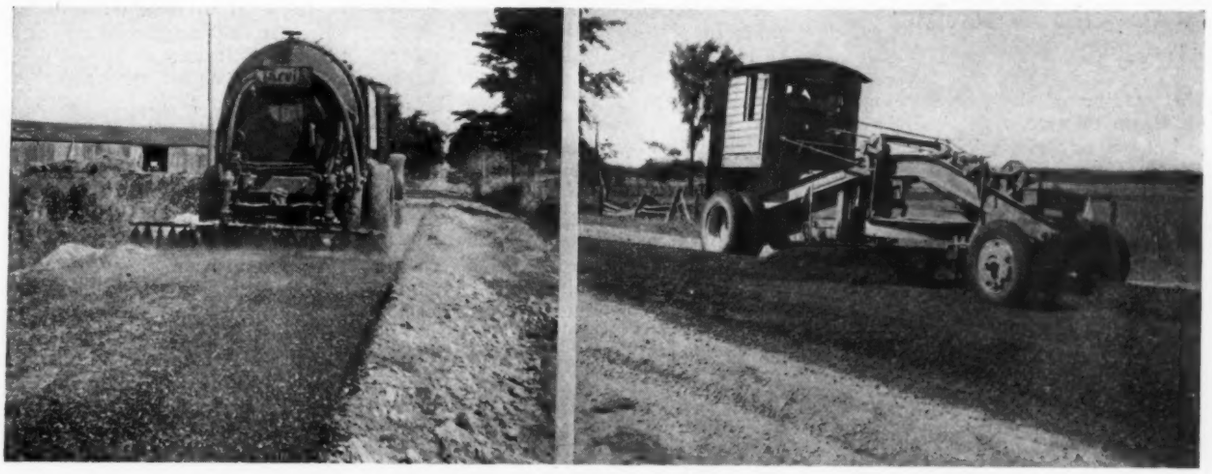
In the *graded aggregate* type of mixture, it is desirable that the compacted mineral aggregate be as dense as possible. Interlocking of the coarser fragments is not essential, but the voids between them should be well packed with fine material containing an appreciable quantity of 200-mesh particles. Such aggregate does not require a strong cementing medium to produce a high load-supporting wearing course, but it is necessary to use a bituminous material with a low initial viscosity to permit of complete and ready mixing with the aggregate, but one that will increase in viscosity thereafter so as to resist displacement by capillary pressure.

In the *macadam aggregate* type of mixture the stability or supporting capacity of the compacted aggregate is dependent principally upon the interlocking of the individual fragments and not upon the packing of the voids with fine material. This natural stability must be materially reinforced with a bituminous binder in order to produce a traffic-carrying wearing course. Because of the probability of internal movement after compaction, the films of binder should be relatively thick. Use of a liquid bituminous product is necessary to insure adequate mixing on the road but its original viscosity should be higher than for the *graded aggregate type,* and it is highly desirable that the bituminous product should harden rapidly after the mixing process is completed. With the development of improved mixing equipment, there has been a trend to heavier products, which, while requiring heating, have the advantage of more rapid setting.

This explains why the two types of road-mix require bituminous materials of entirely different characteristics, a fact most important to bear in mind. Successful results are to be obtained through careful attention to such details.

In making a selection between the two mixed-in-place types, the engineer will be guided by (a) character of the existing highway to be surfaced, and (b) availability and cost of the new aggregate required. If the existing surfaces are of loose gravel, the graded aggregate type of construction is indicated, while old waterbound macadam roads call for the macadam aggregate type even though a fairly long haul for the crushed material is required.

The necessity for adequate drainage



Steps in Road-Mix Construction.

hardly can be over emphasized regardless of the surface type. It is important *first* to check this item before placing the surfacing itself. Adequate culverts and ditches should be constructed. For a year or more before surfacing, and especially during the winter and spring, the old road should be studied with a view to determining any soft subgrade areas or wet weather springs. Bad subgrade areas should be removed to a sufficient depth and a new and solid foundation put in place, and springs should be drained out.

High crowns and "washboards" or pot-holes can be removed by scarifying the old surfacing to a depth of about two inches. This will not disturb the subgrade but it does give sufficient loose material so that, by blading, the crown can be re-established at a proper slope of about ¼ inch to the foot. Necessary new material can then be added.

One advantage of road-mix surfacing is that it may be constructed with the equipment found in every well-organized road department. Tractor-grader equipment is standard throughout the country and experience has demonstrated that many miles of local roads may be widened and drained at low cost with this kind of equipment. After the roads are widened and drained the same equipment can be used for spreading, mixing and finishing the surface course. All contractors also have such equipment, so that whether the work is by force account or by contract it can be done with but little extra equipment cost.

It is desirable to complete the work as rapidly as possible and the rapidity of the operations depends on the number of units employed. The distributor is one unit that governs the rate of progress and, to keep it busy continually, a certain minimum number of other equipment items will be required. This is true particularly of extensive projects. For short sections the use of equipment can be adjusted as the local conditions necessitate.

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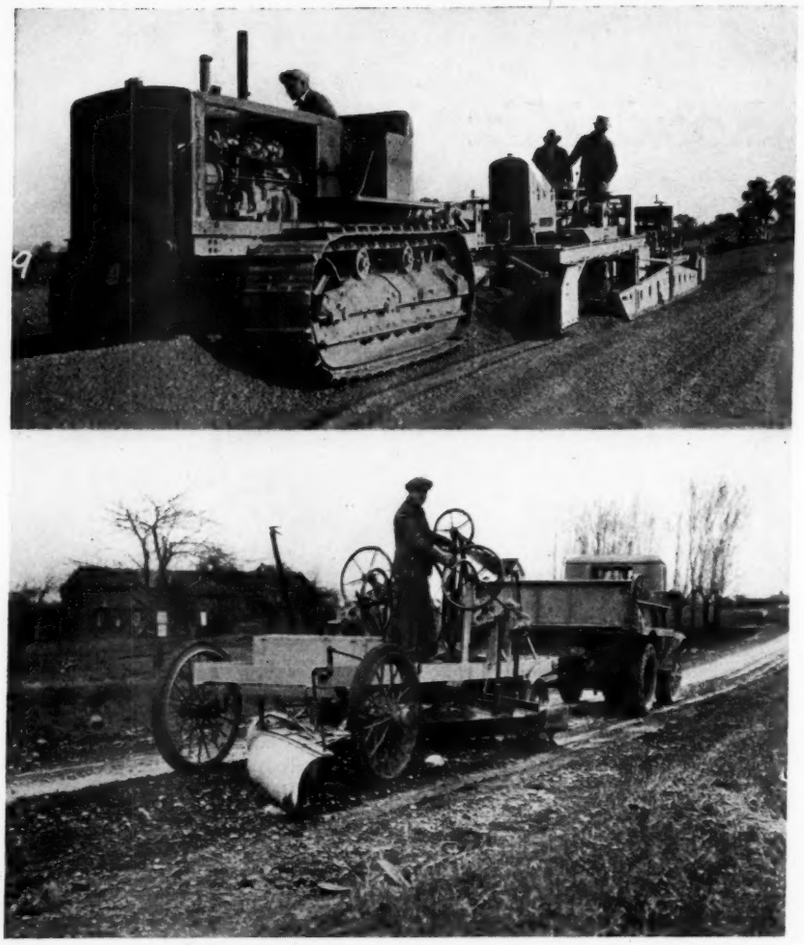
Construction of Graded Aggregate Wearing Course

The grading of the aggregate need not conform to narrow detailed limitations but, on any given job, should be made as uniform as practicable throughout its entire length. Satisfactory general grading limitations are as follows:

Passing one-inch screen	100 per cent
Total passing ¼ inch screen	50 to 70 per cent
Total passing 10 mesh sieve	35 to 60 per cent
Passing 200 mesh sieve	0 to 14 per cent

The old road itself may produce sufficient aggregate by scarifying to the necessary depth. If not enough material is available from the old surface, more must be supplied. This should not generally be done until the scarified material has been sampled and tested for compliance with the table just given. The scarified materal should be bladed into a windrow at the side. Sufficient representative samples should then be taken and tested to indicate where new coarse or fine aggregate and what amount should be added to produce a reasonably uniform grading within the accepted grading limits. Either gravel or crushed stone may be used. Deficiencies of fines in aggregates can be made up with sand or other fine mineral material. In any case that portion of the mineral aggregate passing the 10-mesh sieve should have a field moisture equivalent of not more than 20 per cent and a lineal shrinkage of not more than 5 per cent.

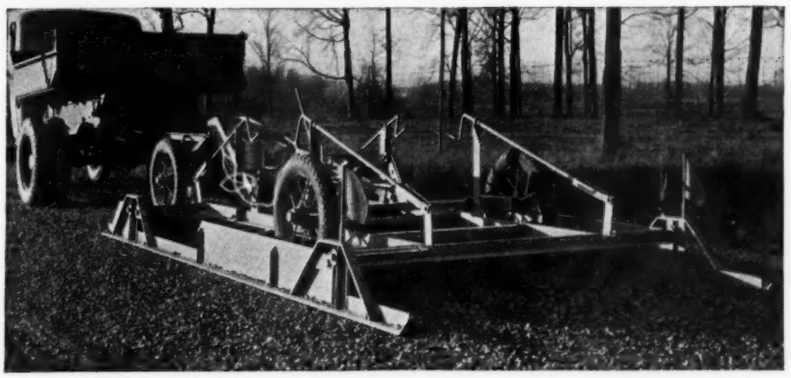


Above, a mix-in-place job in Ohio, and below, a York rake taking out the coarse stone on a New York job.

Use of the correct amount of bituminous material is very important. Investigations have demonstrated that the bitumen should be proportioned more properly upon the basis of void content and surface texture of the compacted mineral aggregate than upon its screen analysis. In determining this, it is important that the mineral aggregate be practically free from moisture. When the proper amount has been determined, it is equally important that the aggregate should be dry before the bituminous material is applied during construction. With wet aggregate, proper coating of the individual fragments is not possible. Moreover, as any moisture which may be present occupies void space in the compacted aggregate, its presence in an otherwise properly proportioned mixture may create a misleading appearance of over richness.

It is impracticable sometimes to prepare the aggregate on the road in a "bone dry" condition, but not more than 2% by weight of moisture should be present when the bituminous material is applied. This will occupy between 4 and 4½% of void space in the compacted aggregate. Proportions, therefore, should be adjusted so that, on a "bone dry" basis, the compacted mixture should contain approximately 6½% of voids.

It is important that all clumps of bonded material in the old aggregate should be broken up by harrowing and blading, after which the loose material should be bladed into a single windrow and sampled for grading. Necessary new material then should be added and thoroughly mixed with the old material by blading and harrowing, after which the mixed aggregate again should be bladed into a triangular windrow of uniform cross-section and measured. From the loose weight per unit volume, the proper rate of application for the bituminous material, per square yard of road surface, to conform to the predetermined proportion then is ascertained. The same method may be used when all of the mineral aggregate consists of new ma-



Galion Planer hauled by a 1½-ton truck. Operated on straight-edge runners 17' 7" long, gives a very smooth surface, and maintains a straight, clean edge by preventing spilling aggregate.

terial purchased on a volume basis. When purchased and used on a weight basis, however, the proper rate of application may be determined directly and without recourse to volume measurement.

Before application of the bituminous material, the windrowed aggregate should be bladed over the road surface in a layer of uniform thickness for the entire width of construction. If wet or damp it should first be bladed back and forth until no free moisture can be distinguished by sight or touch.

The bituminous material should be applied uniformly by means of a pressure distributor. The distrbutor should be equipped with steam coils or some other heating device so that, if for any reason a load becomes too cold for proper application, its temperature may be raised to between 160 and 200 degrees F. Application of the bituminous material should be made for the full width of the road in increments of about ½ gallon per square yard each, until the total required quantity has been applied. For a 2-inch thickness the total quantity will usually lie between 1¼ and 1¾ gallons per square yard—less if the amount of fine material is small—and will involve three or four applications. Between each application the material already applied should be mixed with the aggregate. No application should be made unless the air temperature in the shade is above 50 degrees F.

A tractor-drawn disc or spring-tooth harrow, or multiple blade drags, should follow the distributor immediately for the preliminary mixing and should work up and down the treated strip until all free bituminous material has been incorporated with the mineral aggregate. When the next load of bituminous material is applied, this mixing should be repeated. On a job of any magnitude two mixing units will be required, thus the newly applied material will always be sufficiently combined with the aggregate to permit the passage of traffic without picking up badly.

After the final application mixing of the treated section is continued with one or more road graders. One-man, power-driven bladers are most satisfactory for this purpose. The treated aggregate first should be bladed into a windrow at one side of the road, after which it should be moved in successive cuts to a windrow at the other side, care being taken not to bring in untreated base or shoulder material. This operation is repeated until the bituminous material and aggregate are thoroughly mixed to a uniform color free from fat spots, balls and uncoated particles. More mixing work is required in cool than in warm weather. If the mixture should become wet before the mixing process is complete, the blading operation should be continued until it has dried out.

In the graded aggregate type, additional edge thickness should be provided just prior to the final spread of the mixture from the windrow, by making a triangular cut with the grader at each edge of the base course. This cut should be about 2 inches deep at the outside, sloping to zero at a point about two feet in and toward the center. As the mixture

Spreading, applying the bituminous material, mixing and rolling.

is smoothed out and compacted there is no tendency to make a feather edge, and infiltration of water under the road surface is much reduced.

In the final spreading from the windrows, a succession of thin spreads is preferable to distributing the mixture in a single layer, and provides considerable compaction during spreading. While traffic, light blading and dragging, usually are depended on for compaction, it is advantageous to roll the edges and shoulders with a self-propelled roller weighing 5 to 8 tons where traffic is light and not well distributed. The roller also may be used to close the entire surface when rainy weather threatens before traffic has effected thorough compaction. Traffic and blading compaction may be required for a period of three to ten days before a smooth-riding surface is produced which ceases to be rutted by traffic.

After the surface has been completed, a light seal coat of the same bituminous material should be applied at a rate of approximately ⅛ gallon to the square yard and covered with a very light dressing of sand or fine stone chips, spread preferably by means of a broom drag. Application of the seal coat may be delayed for several weeks but, in damp or cold climates, it should be applied before the first winter, especially with aggregates containing a small per cent of fines.

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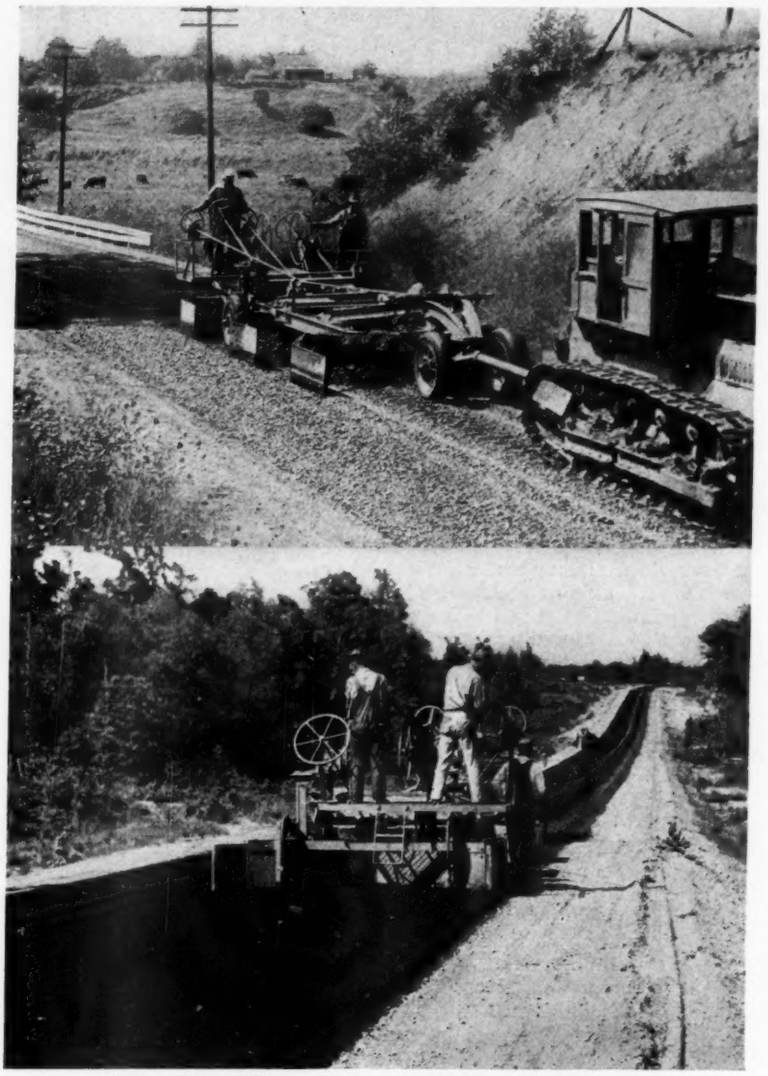
Construction of the Macadam Aggregate Type

Prior to placing the surfacing, the base should be carefully cleaned by sweeping, ordinarily with a mechanical rotary broom, followed by hand sweeping to take care of any small depressions and to clean the edges. With previously treated surfaces, or with waterbound macadam, this is simple. With gravel, chert, shale, sand-clay and similar surfaces not previously treated, care should be taken not to sweep excessively and break the surface bond.

Where the foundation has not been treated previously it is always necessary to prime the surface prior to placing the crushed aggregate. Two objects are thus attained; the hardening and sealing of the foundation, and prevention of loose, dusty material from working up into the wearing course during the mixing operation. The priming application should be made at least 24 hours prior to placing the aggregate and preferably several weeks in advance. The primer material must have complete penetrating qualities and at the same time should contain a bituminous cement base which will harden and cement the surface particles firmly together.

The amount of primer to use will depend upon the character of the base. For previously treated macadam as little as 1/10 gallon per square yard may be sufficient. For well bonded sand-clay, top-soil, shale, chert, gravel and waterbound macadam, ¼ to 1/3 gallon per square yard will be required, while for the more loose and open surfaces ½ gallon or even more may be desirable. The primer should be applied cold by means of a pressure distributor. Absorption usually is rapid, seldom requiring more than an hour.



Adams Retread Paver mixing and finishing a black top job.

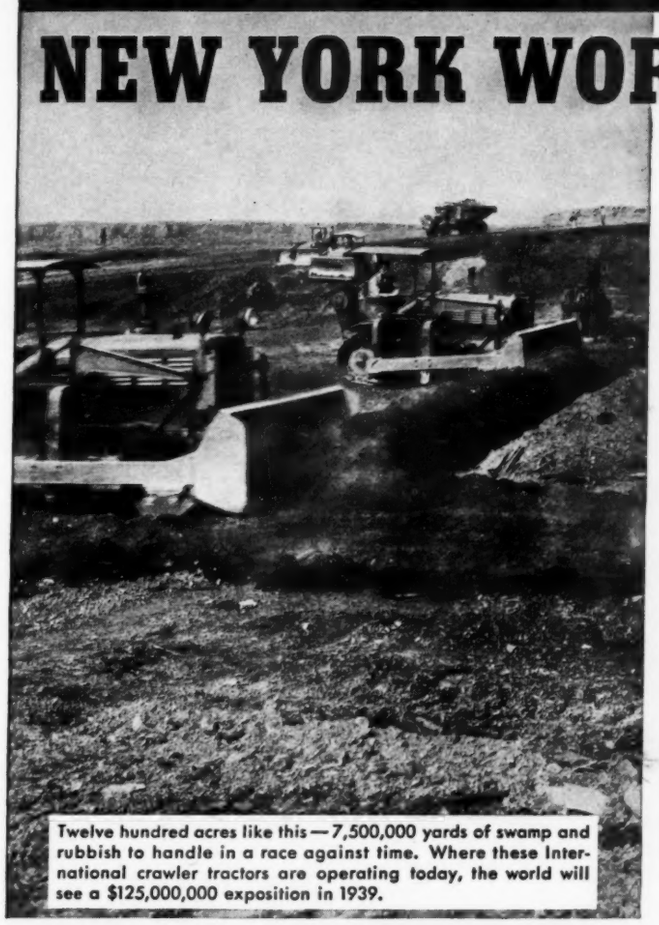
As the stability of the wearing course largely depends upon the interlocking of the individual fragments and not on packing of the voids, the mineral aggregate should be angular in character and of such grading in sizes as will produce the most stable condition. Crushed stone, crushed slag and crushed gravel have all been used with successful results.

For a two inch compacted surface, the best range of size is from ½ inch to 1½ inches, using the commercial run within this range. For thinner surfaces, or where this type is used to smooth rough bituminous surfaces and the depth varies, a smaller size, running from ¼ inch to ¾ inch, is preferred. The smaller size should be used also as mineral cover for the seal coat. Rock from which the aggregate is produced should have a per cent of wear of not more than six. If the aggregate is crushed slag it should weigh not less than 70 pounds to the cubic foot.

For both mixing and sealing operations, it is essential to use a quick-setting bituminous material. With the rapid mixing equipment now available the mixture should be set up completely in one day, and available for traffic the next without any picking up under pneumatic tires.

After the base has been primed, the aggregate should be spread from trucks to a loose depth of approximately 2½ inches. Traffic may be permitted on the road during operations, except just before the first application of bituminous material when the surface should be smoothed with a road grader to insure uniform depth and until the first mixing of bituminous material has been completed. If rain falls on the loose aggregate before the first application of bituminous material, a few passes of the grader will accelerate the drying out and will permit early resumption of the work. The aggregate should exhibit no free moisture when the bituminous material is applied.

INTERNATIONAL Crawler Tractors
LAY GROUNDWORK FOR
NEW YORK WORLD'S FAIR 1939



Twelve hundred acres like this—7,500,000 yards of swamp and rubbish to handle in a race against time. Where these International crawler tractors are operating today, the world will see a $125,000,000 exposition in 1939.

The ancient Brooklyn Ash Dump in the Flushing Meadows on Long Island—miles of man-made desert where Manhattan and Brooklyn have heaped their rubbish for forty years—is a scene of great activity this winter. In 1939 New York City will entertain you there at a greater World's Fair.

Right now it's a job for the Johnson-Necaro Co., who shouldered a $2,000,000 contract to handle 7,500,000 yards of tangled refuse in a race against time. On April 1 they will deliver parks and lagoons where they took over chaos in the form of ashes and old iron.

The Johnson-Necaro Co. is coming on fast with International TracTracTors—the crawler-tractor product of International Harvester. A fleet of T-40 TracTracTors and bulldozers has been on the job for months now, handling 90 per cent of the vast yardage of material coming from the shovels and dump wagons.

Out there on Long Island today W. R. Staehlin, general superintendent, will tell you about how much these tractors can take, and how they perform while taking it. William Beattie and Charles Downing, chief engineer and general master mechanic, respectively, prove to us that what we claim about International service, and about accessibility of working parts, is understatement. And A. D. Saunders, operating vice-president, goes over the whole matter and says "That goes not only for me but for everybody on the job. I'd duplicate the entire order right now if we needed to."

This wouldn't mean so much coming from a green outfit, but the Johnson-Necaro organization is "tops" in the East. They have taken care of a $200,000,000 total in subway, tunnel, and other work in Metropolitan New York. They know crawler tractors from A to Z—*now.*

• • •

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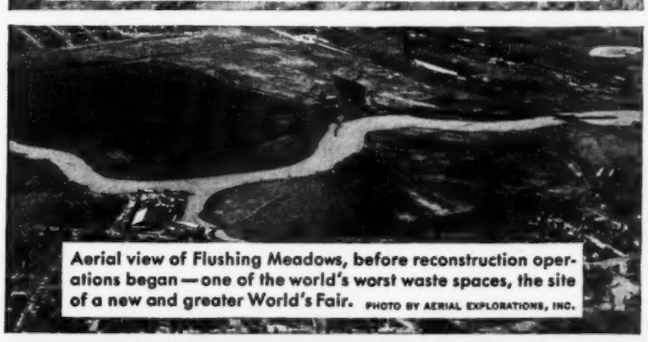
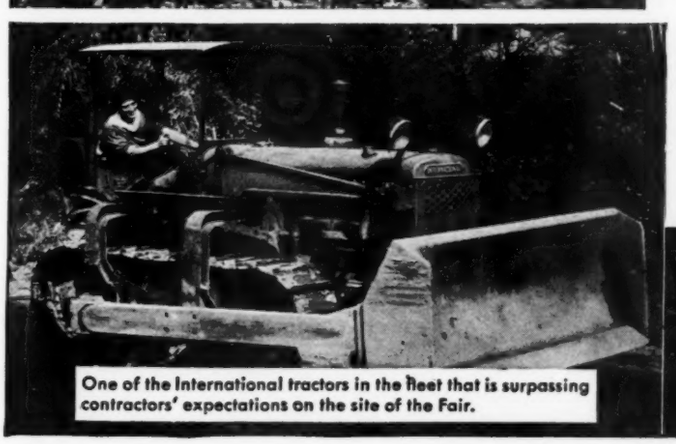


Aerial view of Flushing Meadows, before reconstruction operations began—one of the world's worst waste spaces, the site of a new and greater World's Fair. PHOTO BY AERIAL EXPLORATIONS, INC.



One of the International tractors in the fleet that is surpassing contractors' expectations on the site of the Fair.

W. R. Staehlin, general superintendent of the Flushing Meadows project. His grandfather held the chair of mathematics at Heidelberg, but Staehlin is no "chair" man. Thirty-two years on the job for the Arthur Johnson Co. have taught him volumes about the practical handling of heavy contracts. A big revelation to him of late has been the efficiency and economy of International TracTracTors.

INTERNATIONAL HARVESTER
INDUSTRIAL TRACTORS . . . POWER UNITS . . . TRUCKS

Bituminous material should be applied in three applications, one or two in connection with the mixing operations and one or two for the seal coat, and should be warmed to insure uniformity of coverage. Two applications of approximately 0.4 gallon each are made, or one of 0.8 gallon. The seal coat should be placed several weeks after the mixing operations have been completed. A pressure distributor, preferably one operating on pneumatic tires, should be used for all applications.

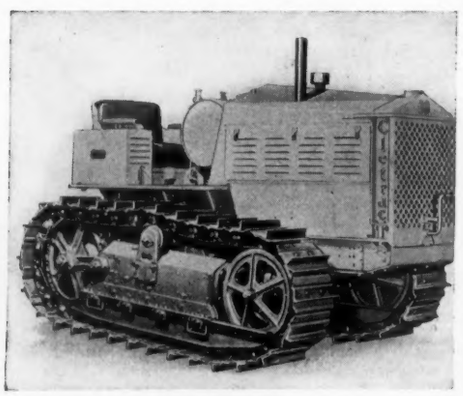
After the application of bituminous material, the aggregate and asphalt should be mixed thoroughly by special road-mixing equipment such as multiple-blade drags or maintainers, pin mixers or other suitable device until the bituminous material is evenly distributed over the aggregate, which may require several passes, depending upon the design of the equipment. Mixing and blading should be continued until the bituminous coatings become "tacky" and begin to set up, when the mixture should be bladed out to a uniform depth and dragged. A drag is advantageous in the final stages of the set-up since it does not gouge the surface and insures smooth riding qualities. Several new spreading and leveling machines recently have been put on the market that take the place of the drag and produce very smooth surfaces with greater speed.

Where rapid work is necessary because of traffic one-half the roadway width may be built in one straight-away mixing operation, using several mixing units behind one another, with the bituminous material applied in one application and with no turning of equipment. A high viscosity bituminous product is employed, and rolling is begun not more than an hour after the mixing.

Compaction is obtained by rolling with a three-wheel roller of approximately 10 tons weight where a 2-inch thickness is being laid. For lesser thickness, 5 and 8-ton rollers are used with good results. Rolling should be done in accordance with standard practice, the roller running longitudinally, beginning at the edge and working toward the center with each trip overlapping the prior trip by about one-half the width of the front roll and in such manner as will key the aggregate well together and produce the greatest density. Several weeks after the completion of the surface course and when all areas are thoroughly stabilized, the seal coat should be applied, using the same bituminous product as that used in the original mix. A cover coat of 15 to 18 pounds per square yard of fine aggregate should first be spread uniformly over the surface and lightly broomed into the surface voids, after which ¼ gallon per yard of bituminous material should be applied, and the surface broom-dragged, so that the chips and bituminous material become thoroughly mixed and spread. In some cases a double surface treatment is desirable to waterproof the surface. Rolling with a three-wheel roller, as soon as the bituminous material sets up, produces a durable surface of exceptional smoothness. A light application of from 5 to 10 pounds of fine aggregate may be added during the final rolling to give a light grey color to the finished surface and to take up any slight excess of bituminous material.

Edge failures are not common when the base is sufficiently thick to carry the traffic loads, but it is good practice to have the base a foot or two wider than the wearing course. Where this is not done the adoption of a minimum 18 to 20 foot width practically eliminates any tendency to wear down the edge.

Mixing bitumen with aggregate.



One of the Cletrac line of tractors.

Bituminous Macadam

As in any surface, preparation for bituminous macadam construction should begin with drainage. Adequate ditches and culverts ample in both number and size are not enough in most areas; subdrainage will also be needed to prevent saturation of the subgrade during wet periods. Following completion of drainage work, the subgrade should be shaped and then rolled.

Much of this type of surface was built under the WPA, because local stone was usually available, and the base course could be placed on the road and broken or pounded down by hammers; also, the same was not infrequently done with the top course. Asphalt or tar was then spread, by distributor or otherwise, a cover coat of stone dust, shale, sand and gravel, or just plain dirt shoveled on, and the whole rolled.

Even roads as sketchily constructed as these, give good results, and the cost is not great, generally $3,000 to $4,000 per mile! But really well constructed bituminous macadam surfaces give quite remarkable service. New York State built many miles of this type nearly 20 years ago, much of which is still in satisfactory service. Modern surface treatments or road mix surfaces have since been added to produce a smooth riding surface. Among these are the Liberty-Callicoon road, originally built in 1909, and given a road mix surface some three or four years ago. The Massachusetts highways are among the notable examples of this type.

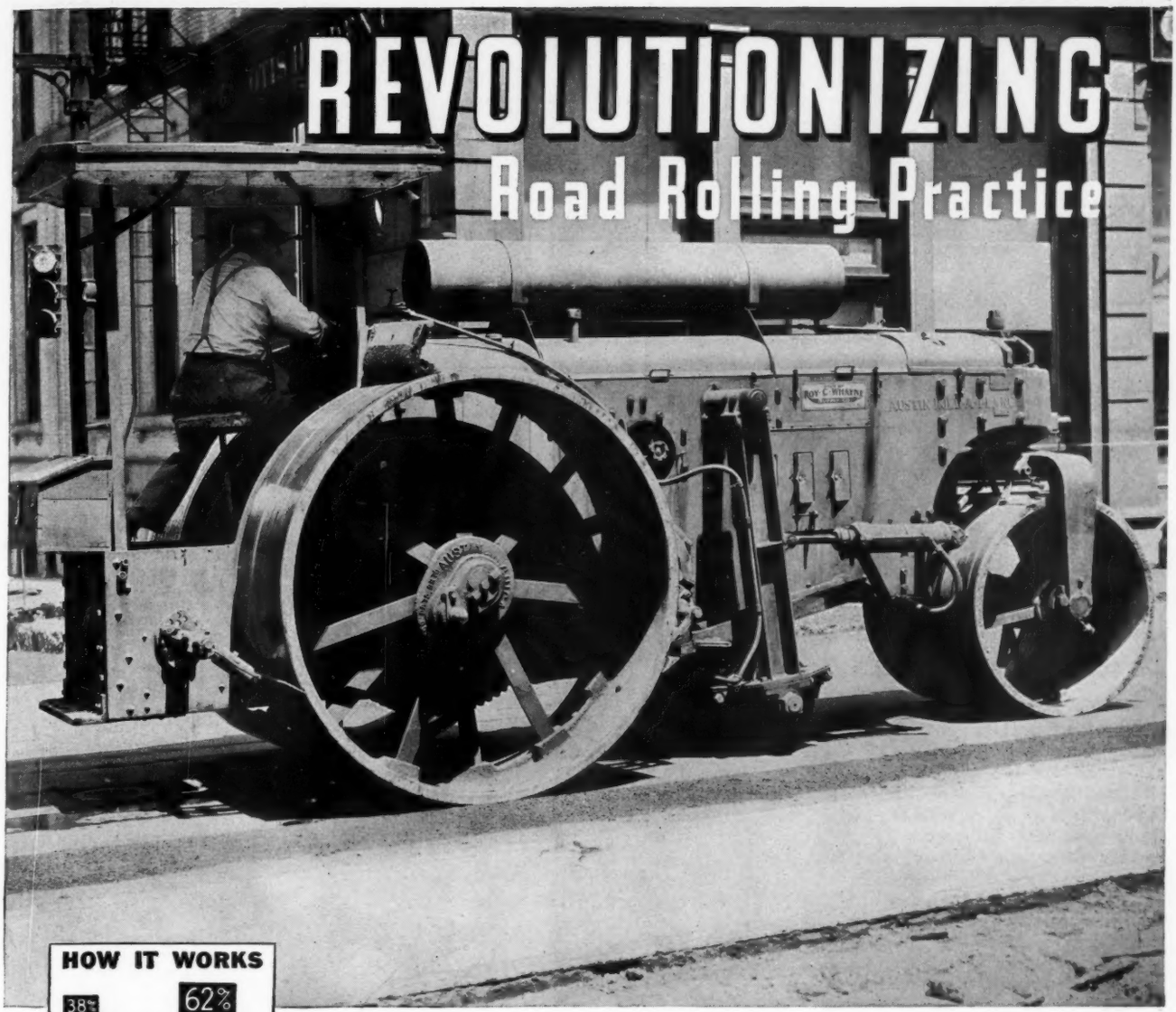
Procedure in Construction

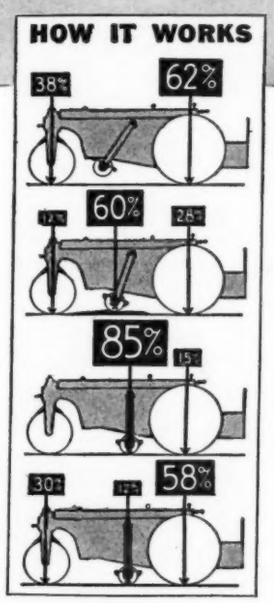
After the drainage and rolling of the base, stone is spread for the base course. If commercial aggregates are available, this should preferably be 1½ to 2½-inch stone; but if the product of a crusher must be used these limits need not be observed strictly. This layer, when compacted should be 4 or 5 inches thick and its top should be about 2½ inches below the finished surface. This base course should be rolled very thoroughly, until the roller marks no longer show on the surface. In order to provide lateral support for the top or wearing course, it is desirable either to roll the shoulders, or to carry the base course 12 inches or so beyond the width of the top course. When this is done, the shoulder should be brought back against the top course, and rolled. A bituminous treatment on the finished shoulder is desirable.

After the base course has been thoroughly rolled, a binder or filler of sand or stone dust is spread on the surface and broomed into the voids, after which rolling is continued. An excess of the filler is not desirable and should be broomed off.

The top or wearing course should be of good stone. Massachusetts, which is most rigid perhaps of all in the requirements for materials and methods for

REVOLUTIONIZING Road Rolling Practice





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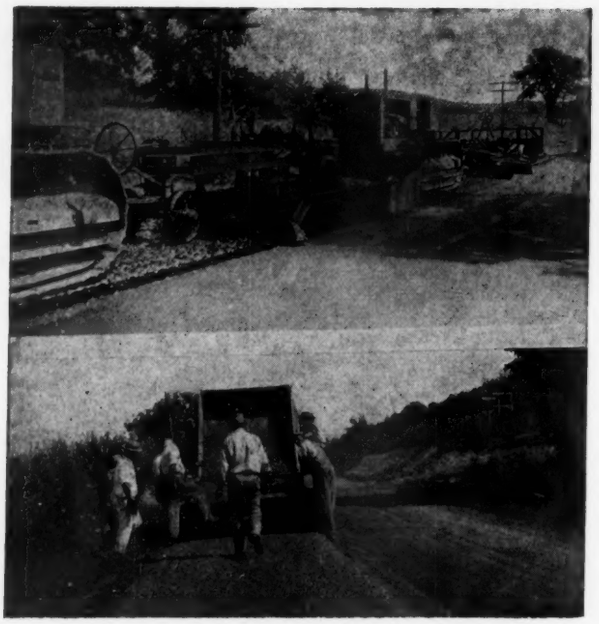
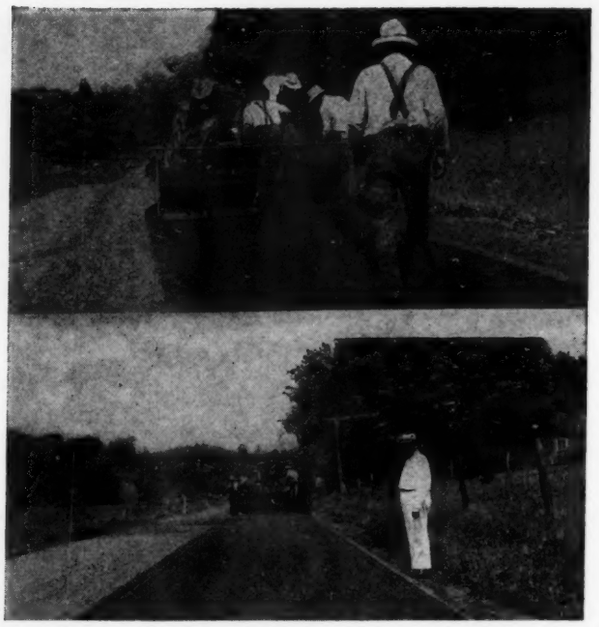


Top—Road-mix equipment in tandem. Finisher in rear. Note (at extreme right) truck passing along the work.

Bottom—Spreading aggregate. Note uniformity of width and surface. This spreader has spread as much as 1,100 tons in one day.



Top—Applying asphalt powder on oil-coated aggregate ahead of mixer.

Bottom—Road oiled aggregate and asphalt powder. S. R. No. 41 in Highland County.

penetration macadam, requires a French coefficient of wear of not less than 14, a toughness of not less than 12, and a size of 1¼ to 2¾ inches. Such stone is not always available within reasonable limits of cost, in which case softer, or smaller sized aggregates can be used. Construction procedures must then be varied to meet these conditions. In general, the smaller aggregates require that the bituminous material be spread in smaller applications, and that it be a softer cement, such as emulsion or a rapid curing cutback. The softer aggregates, which may crush under rolling so that almost no voids remain, require but little rolling and the use of a highly penetrating bituminous binder.

With good stone, the entire application of bituminous material may be made at once. Generally this is 0.8 to 1 gallon per square yard per inch of depth. The smaller amount permits the wear to come directly on the aggregate. If softer stone is used, the amount of bituminous material may be increased slightly. But when the small or soft aggregates are used, several applications of bituminous materials must be made, since with the denser surfaces due to smaller aggregates or to the use of soft stone that crushes under the roller, a similar penetration is not possible. Also, as previously noted, a different variety of bituminous material is desirable.

Spreading of the stone for the top or wearing course should be by means of mechanical spreaders in order to obtain a smooth riding surface. After spreading, the surface is rolled lightly, low spots are brought up to grade and high spots removed. After this trueing up, the surface is rolled thoroughly until the passage of the roller does not leave any marks on the surface.

Immediately after the application of the bituminous material, as already described, chips or pea stone are spread on the surface—only enough being used to fill the voids—and rolling is continued. If necessary, additional chips or pea stone are spread as rolling progresses, but any excess should be swept off and the surface left clean for the application of the seal coat.

The final treatment consists of the seal coat. For tough and hard stone, ⅜ to ½ gallon of bituminous material is applied, covered lightly with pea stone or gravel and rolled. As rolling continues additional cover stone is added as necessary and broomed into the voids. Massachusetts recommends the use of a 10-ton or preferably heavier roller for this final rolling.

With slightly softer stone, it may be desirable to add a somewhat heavier seal coat application and to cover it with more aggregate, so as to produce a dense and waterproof wearing surface.

Bituminous Stabilization

Considerable attention has been given to stabilization during the past year and various technical papers have served admirably to present concisely the procedure to be carried out when using deliquescent salts.

Soils are made up of three principal constituents—silt, clay and sand. Each group has certain definite charactertstics and dirt roads behave according to the proportion of these three materials that is contained. In the sand-clay surface, these two constituents very nearly balance one another to insure stability the year around, but this perfect balance is rarely found in nature. Soils usually contain a preponderance of one or another of these elements, and in order to develop the highest stability, it is usually necessary to add additional amounts of material, either fine or coarse.

With all the materials used for stabilization, such as calcium chloride, salt, asphaltic materials and tars, and portland coment, the whole effort is to approach the naturally high stability obtained when the right amount of moisture is present. Practically all soils, when at the optimum moisture content, have a bearing power of over 50 pounds per square inch; some of them can support over 100 pounds per square inch, and consequently have a considerable margin of safety for light and medium traffic.

★ ★ ★

Silt Soils:

Silt, silty loams and silty clays, wherein the silt is the predominating constitu-

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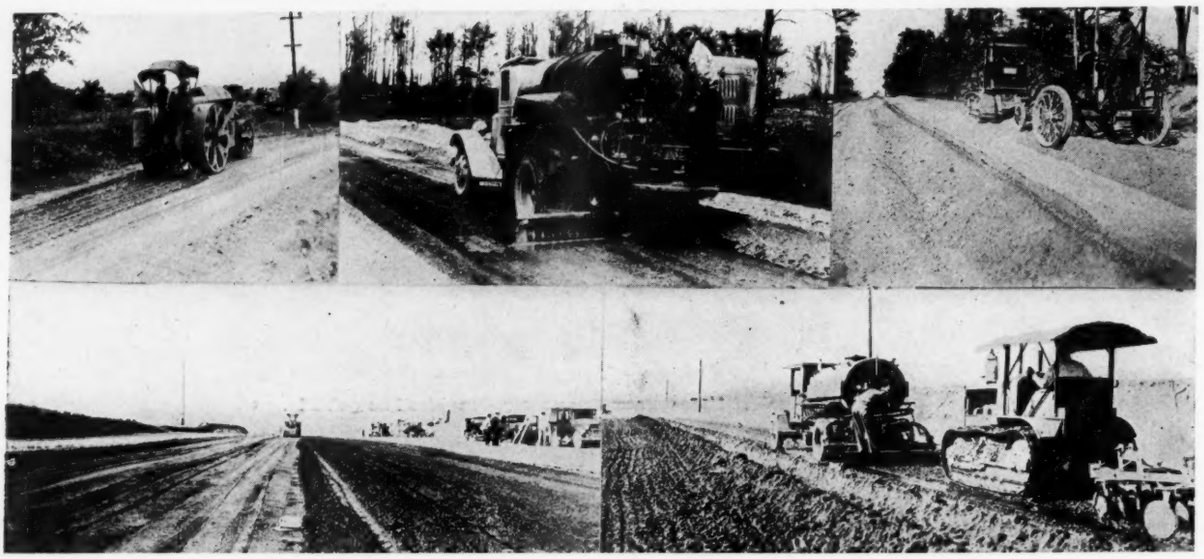
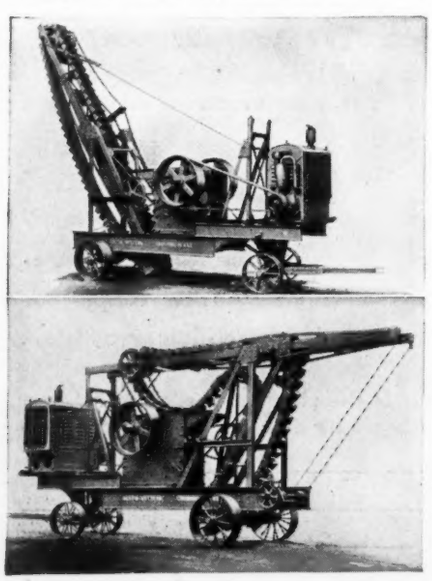


The top row of pictures shows steps in stabilizing. At the left, scarifying; center, wetting the subgrade; right, mixing the dry materials. Below, bituminous emulsion stabilization in California.

ent, make the most unstable kinds of dirt roads. When confined, however, these silty materials develop considerable stability and, by incorporation of a suitable bituminous material a good durable surface may be obtained.

Early in the spring the road surface is carefully bladed to a true and even cross-section, pains being taken to insure a uniform condition of surface, which is all-important. Due to the rapid loss of moisture from silty soils in hot weather, it is desirable to do the final blading of the surface immediately in advance of the application of the bituminous material,—the same day if possible. By so doing the upper layer of the roadbed is made slightly moist, which causes a bulking of the earth, thus permitting the ready absorption of the bituminous material. In the event that the roadbed has dried out and become dusty, the loose dry material should be bladed to the side of the road to expose the relatively moist material underneath.



Small portable crushing plant (Austin-Western) well adapted for low cost road construction.

Upon the roadbed thus prepared is applied the bituminous material at the rate of 0.5 gallon per square yard, which is allowed to be entirely absorsed without any cover coat. Where practicable, the road is closed to traffic and the entire roadway width treated. Where detouring is not possible, the application is made to one-half the roadway. Traffic should be kept off the freshly treated surface to permit uniform absorption, to prevent tracking and cutting the new surface, and also to prevent splashing of passing vehicles.

As soon as the first application is completely absorbed, a second is made at the rate of 0.25 gallon per square yard and permitted to soak in as before without any cover coat. Traffic is then permitted to use the surface.

A third application of 0.25 gallon per square yard is made several days to several weeks afterward, according to the appearance of the surface, to insure the complete admixture of bituminous material with all earth particles near the surface,—making a total of one gallon per square yard in all. This is likewise allowed to be absorbed without any cover coat. Where a road is completely closed to traffic, the three applications are made as rapidly as each one is absorbed; while when applied to one-half the roadway, they are given as rapidly as convenient.

★ ★ ★

Clay Soils:

For the purpose of treatment, clays are classed according to their capillarity, —that is, their ability to draw up water from the ground water level underneath the road surface. The two groups are: the non-capillary group of finely divided clays in which capillary moisture does not rise more than a few feet; and the group in which capillary rise of water may range from ten to a hundred feet or more. These different kinds of clay, when used in road building, show little difference in behavior under the admixture of surface water, the effect of capillary water being hardly discernible. However, when the surfaces are waterproofed and the roadbed has become consolidated, the non-capillary clays will maintain their stability all the year around while the highly capillary ones show more or less break-up because they become saturated and plastic from the *rise* of ground water.

★ ★ ★

Treatment of Non-Capillary Clays:

Methods of preparation of the surface have been described. The first application of bituminous material is at the rate of 0.3 gallon per square yard. This is allowed to soak into the surface without any cover coat in order to impregnate thoroughly the upper part of the roadbed and provide a bond with the seal coat and gravel cover. The second application is then made at the rate of 0.3 to 0.5 gallon per square yard, and covered with 50 pounds of gravelly sand; the surface then is bladed until the gravel and bituminous material are thoroughly mixed. The mat so formed is dense and impervious to surface water, yet sufficiently flexible to permit such rebladding as may be needed to correct depressions and prevent the formation of any cracks or crevices, should the clay subgrades further compress. Once settlement has been completed, further maintenance is by blading or patching occasionally as needed.

★ ★ ★

Treatment of Highly Capillary Clays:

Highly capillary clay soils present the most difficult problem in treatment work, as they also do when used as a subgrade

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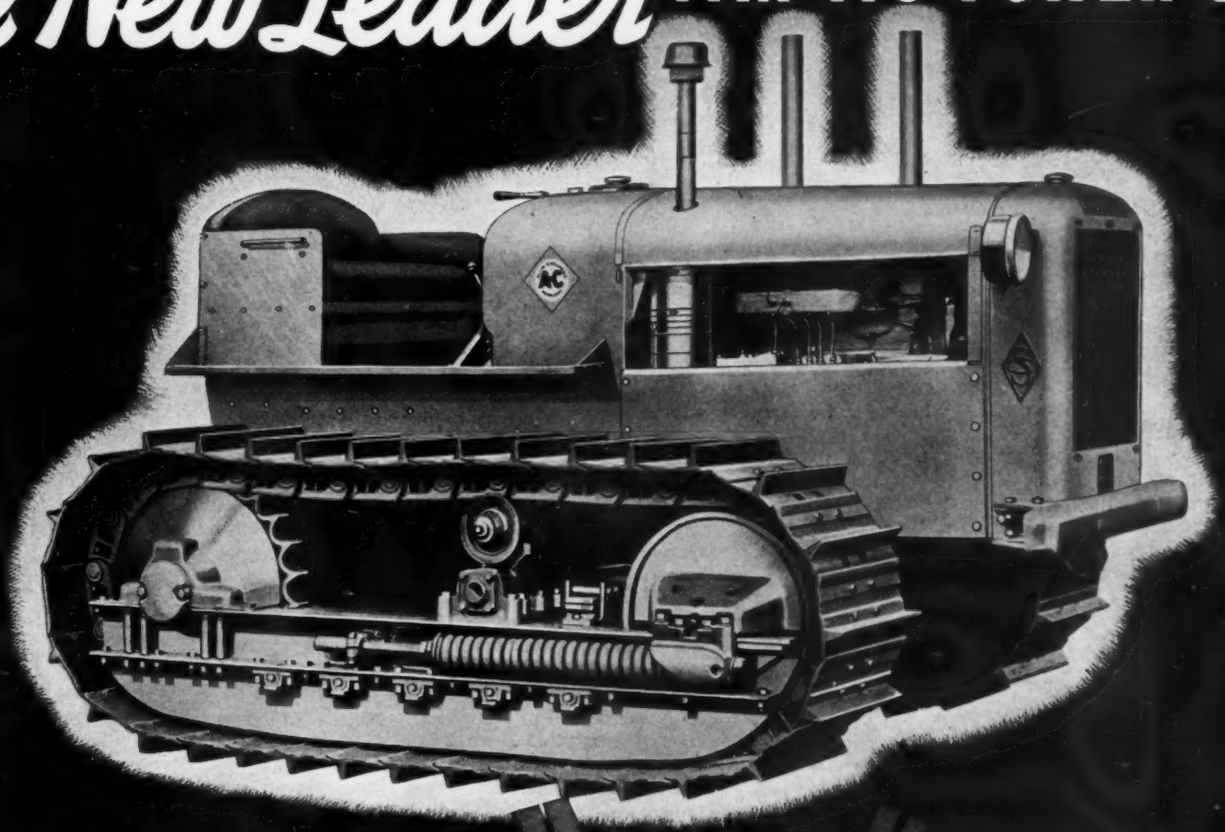

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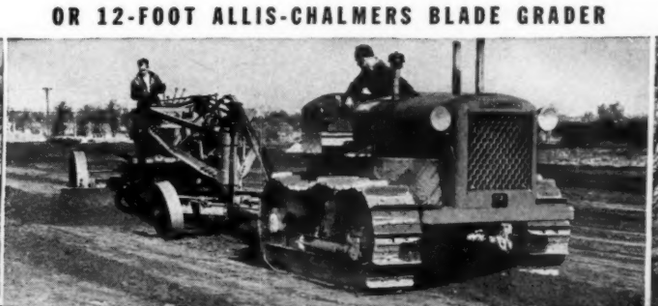

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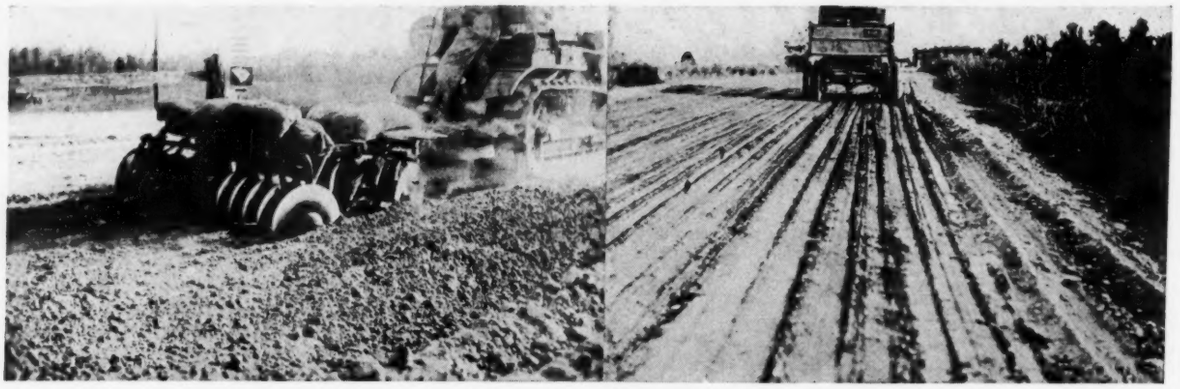


Mixing and compacting a cement treated road in South Carolina.

under more expensive paving. Such soils even though waterproofed from above may still become saturated from the rise of ground water and have little or no support value.

★ ★ ★

Sub-Oiling Operations

The sub-oiling machine is a tooth scarifier with the teeth spaced approximately 2¾ inches apart, and having an oil line attached to the each tooth. In hard or quite thoroughly compacted soils, the roadway is first scarified. The sub-oiler, pulled by a truck or light tractor, then follows down the roadway with teeth set to penetrate to a predetermined depth. A bituminous distributor or supply tank accompanies the sub-oiler and provides bituminous material, which is pumped through the oil lines into the soil at the rear of each scarifier tooth. After application the road surface is levelled with a motor grader and rolled with a 5-ton 3-wheel roller. By application at the proper depth beneath the surface, the overlying soil will become gradually permeated, making it water repellent and stable under varying moisture conditions.

It is believed by some that with silt and clay soils, an abundance of moisture is essential in order to expedite dispersion of bituminous materials throughout the overlying soil. At any rate, general rains prior to and during early experimental work wetted the soil quite thoroughly and aside from some mechanical difficulties, oiling operations were successfully carried on under conditions that would have stopped other types of highway work. According to this theory and experience, it would seem that in early spring just after the frost has gone, with the soil fluffed and moist, the most favorable natural conditions for this work would occur.

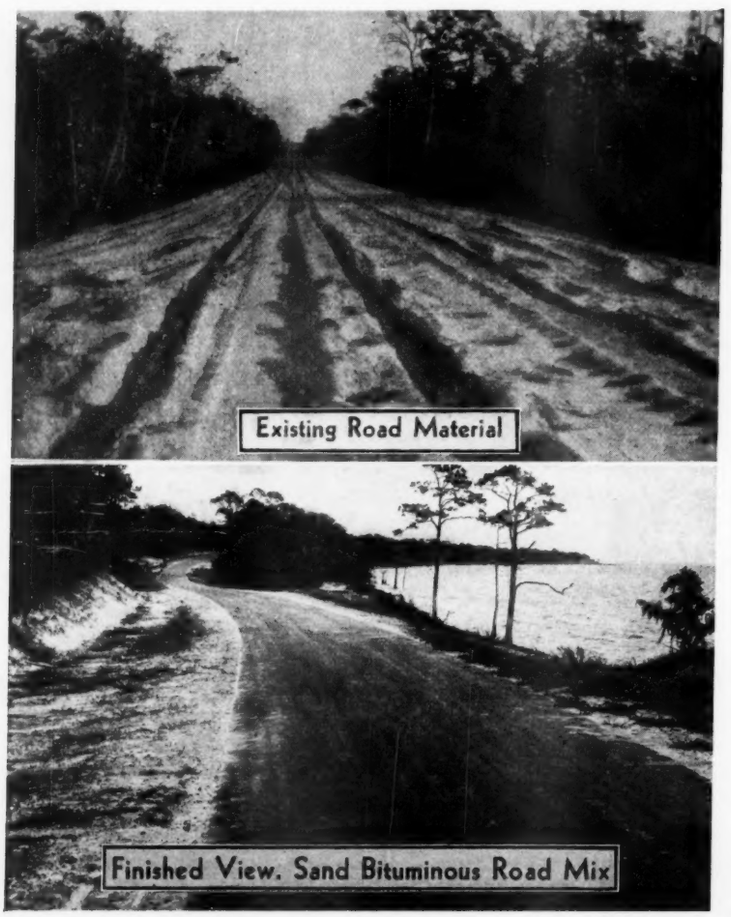
The quantities of bituminous material used varies from 2 gallons per square yard to 3.8 gallons per square yard. Depth of treatment varies from 2½ to 5 inches. For average conditions, it is thought treatments should be from 4 to 6 inches in depth. The amount of bituminous material required will vary from ½ gallon to ¾ gallon per square yard per inch depth of treatment. In extreme cases as much as 1 gallon per square yard per inch thickness may be found necessary.

Generally similar results can be obtained by scarifying the desired depth, breaking the clay into small particles, windrowing to the sides of the road, and then placing alternate layers of clay and bitumen and mixing with a disc harrow or similar machine.

Another possibility is to treat the soil at two different elevations, one approximately a foot below the surface, and the other at the surface itself. Some form of sub-oiler may be used, or the earth removed to one side for one-half width of roadway, the exposed surface treated and the soil replaced, followed by similar procedure on the other half.

Still another method tried experimentally in Australia, is the baking of the prepared surface to form a kind of soft brick. A form of surface heater is employed which moves slowly over the road surface, hardening it to a depth of about 2½ inches. A surface treatment with a light bituminous primer is then given, followed by a soft bituminous cement and granular cover coat. Fair results from this method have been reported.

A method already in successful operation in several states is that of incorporating a coarsely woven cotton fabric (mesh ⅛ inch by ¼ inch) in the surface treatment. Briefly, the procedure is to prime



Treatment of soils such as this are discussed on the following page.

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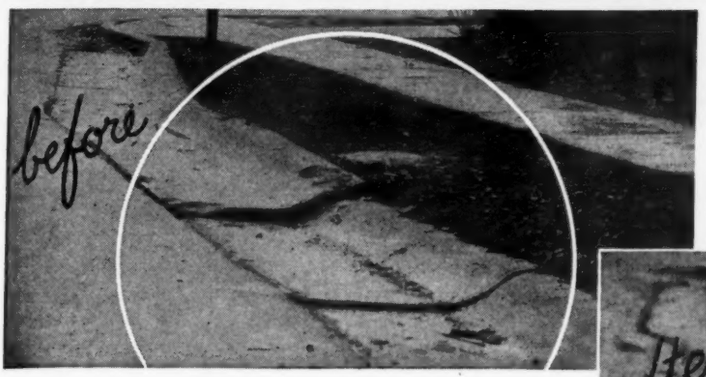

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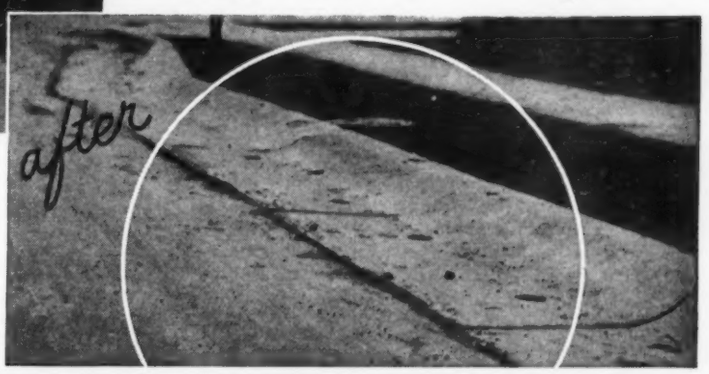

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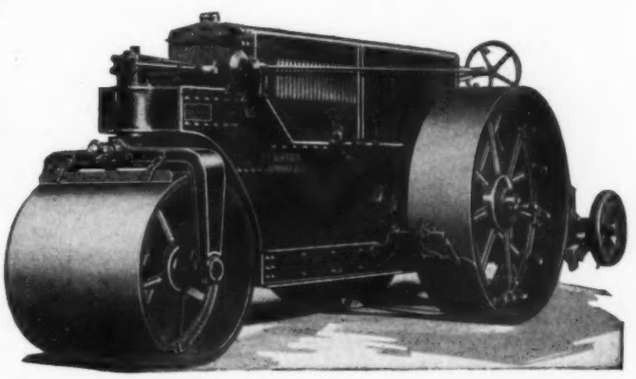

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When you need special information—consult the *classified* READERS' SERVICE DEPT., pages 67-69

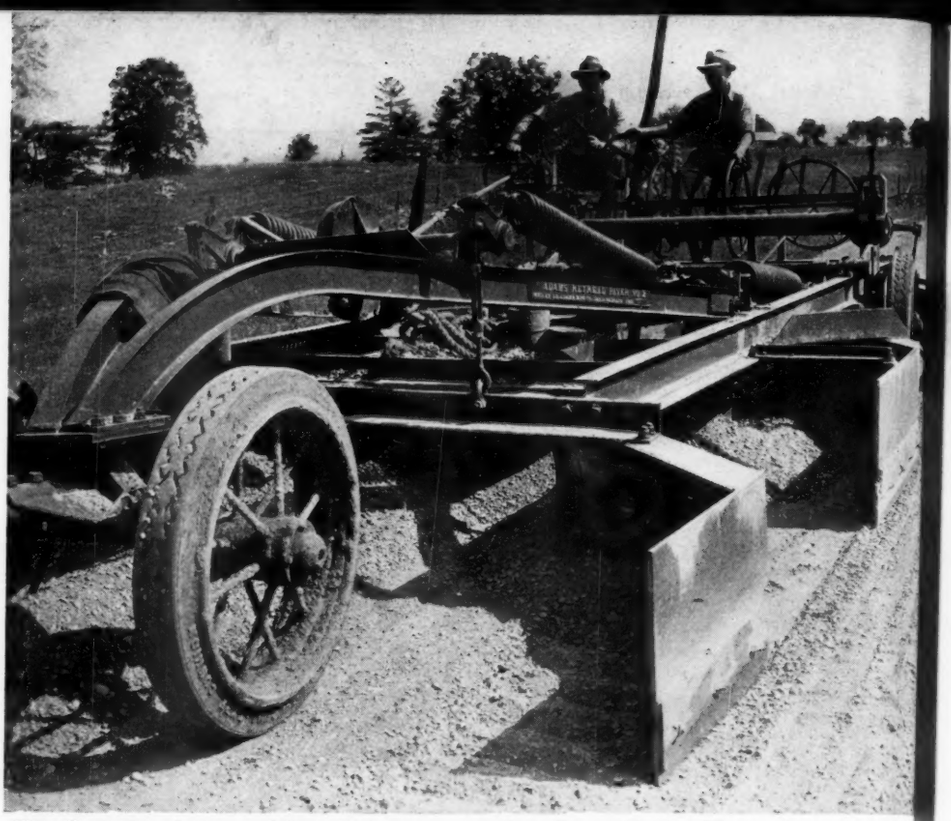
the surface, place the fabric in long strips on the surface, then apply the heavy bituminous seal coat, cover with aggregate and roll. The fabric as impregnated is durable and tends to reduce ravelling and breaking of the mat under softened subgrade conditions. The first work of this kind was placed in South Carolina in 1926-1927, followed by other projects in Texas in 1930; in Sheffield, England, 1930; in Georgia, 1931, and in Louisiana, 1932. The cost of the fabric in place is about eight cents per square yard and there are undoubtedly many locations where such reinforcement will prove an economical procedure. The Cotton Textile Institute, New York City, is carrying on further studies in this field.

★ ★ ★

Treatment of Sandy Soils:

After the roadbed has been carefully conditioned and just before the first application of bituminous material, a small amount of earth is bladed to the side of the road in a windrow, a depth of about one inch being usually enough. Application is then made at the rate of 0.6 to 0.8 gallon per square yard and immediately followed by blading back the earth previously removed. One-man grader outfits or tractor-drawn graders are usually employed and the blading is continued until the surface is smooth and even. The bituminous material gradually absorbs this cover but, if bleeding occurs, additional earth is applied to absorb it. An excess covering of earth should not be used as it makes a crumbly mat. As pneumatic-tired traffic soon irons out the surface, it is a peculiarity of this type of treatment that traffic consolidation is better than rolling.

As soon as traffic begins to break through this first application, which usually will be in about one or two months, the surface should be scarified and pulverized to a depth of 2 or 3 inches, rebladed and made uniform; then a second application of bituminous material is made, covered with earth and manipulated as in the first treatment. This second application will vary from 0.5 to 0.8 gallon per square yard, depending on the amount of clay or silt particles present in the sand which affect the absorption of the asphaltic material. The finer the texture of the soil the greater the quantity required. The proper mixture can be determined by inspection after a few days traffic. Too little will produce a crumbly surface; an excess will make a fat surface. Either condition may be quickly remedied, however, either by a light additional treatment in the first instance or scarifying and reblading in the second one. Usually two applications are sufficient, but the next year the same procedure of treatment is again followed and, subsequently additional applications are given as conditions require, the whole procedure being carried on with view to building up gradually a dense, waterproof surface over a period of two or three years.



This illustration shows an Adams Maintainer at work in Brown County, Wisc., where more than 40 miles of road-mixed stabilized surfaces have been constructed during the past three years.

Calcium Chloride and Salt Stabilized Roads

Roads of this type cannot be classed as bituminous roads, yet they deserve a place in this discussion because stabilized roads of this type are becoming more and more looked on as suitable bases for bituminous treatments.

In the construction of stabilized roads, it is primarily necessary to obtain the proper grading for maximum density, and then to make provision for the maintenance of the proper moisture content. This latter is generally obtained by adding calcium chloride or salt to the mixture of soil, these salts having the property of absorbing moisture and retaining it over a considerable period of time. The principles of stabilization are well stated by the Calcium Chloride Association as follows:

(1). *Density* is obtained by a proper gradation of sizes ranging from 1-inch stone down through the successively smaller sizes of coarse sand, fine sand, silt and clay. Compaction by rollers or traffic in the presence of proper moisture content is also a factor in securing density. Samples cut from well compacted stabilized wearing courses show a unit weight of about 150 pounds per cubic foot, which equals the weight of concrete.

(2). *Internal Friction* is the resistance of the particles to sliding over each other and is furnished by the sharp sand or crushed stone or gravel. The wedging or keying action is obtained by the use of rollers or the weight of traffic.

(3). *Cohesion* is the resistance of the soil and stone particles to being pulled apart. It is furnished by the clay used in the mixture, and by the moisture that is introduced at the time of construction and preserved by calcium chloride. Moisture films surrounding the soil grains cause these to adhere to each other with remarkable force.

Initial Procedure

The first procedure is to analyze the soil of which the road is composed in order to determine its characteristics and also the amount and character of materials that must be added in order to provide maximum stability and density. The stretch of road to be sampled should be inspected and divided into sections in which the soil composition is roughly uniform. For each uniform section, about six samples are taken with a soil auger, at about equal distances and from both sides of the roadbed. These should represent the top 6 inches of surface, and another set of samples should be taken to show the subsurface conditions. The samples from each uniform section of the top 6 inches should be composited.

The gravel or soil pit from which it is planned to obtain material for the road surface should also be sampled. All of these samples—those from the road and from the pit—should be analyzed by screening to determine their composition. and the liquid limit, plastic limit and plasticity index should be determined.

"GREATEST DISCOVERY in Road Construction in Years"

MAKES YOUR BUDGET GO FURTHER

The construction of soil-stabilized secondary roads throughout the country is the recently announced aim of the U. S. Bureau of Public Roads, who consider it "The Greatest Discovery in Road Construction in Years." Most other engineers, both state and county, voice the same sentiments and have scheduled extensive mileages of stabilized road projects for 1937.

The rapid acceptance of stabilization with mixtures of locally available soil materials is truly phenomenal, but not at all surprising, since it solves a problem that has confronted road engineers for years. Far-sighted highway officials appreciate that the secondary roads of today will, in many cases, be the primary roads of tomorrow, and they have found the answer in stabilization. It offers, at extremely low cost, an immediate firm-surfaced wearing course which, when conditions demand, will form an unexcelled base for higher-type surfacing.

During the next decade, the greatest activity in road-building will be on secondary and farm-to-market roads. Stabilized roads—easy to build and easy to pay for—fill every requirement for a firm and smooth, dustless, year-round road.

Stabilization has gone far in the past year—much new scientific and practical knowledge has been gained. Write now, to any of the firms listed below, for complete information on how to build 1937 model calcium-chloride-stabilized roads, streets, drives, parking areas, etc.

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CALCIUM CHLORIDE

FOR STABILIZING ROAD SURFACES

Pioneer portable mixing plant for producing stabilized material.

Composition and Materials

Various recommendations have been made for the composition of the wearing course. The following represents good practice, other recommendations varying only slightly:

Passing:	*Per Cent*
1-inch sieve	90 to 100
¾-inch sieve	80 to 100
⅜-inch sieve	50 to 90
No. 4 sieve	40 to 75
No. 10 sieve	30 to 55
No. 40 sieve	20 to 35
No. 200 sieve	10 to 20

For a base course, material passing a 1½ inch screen is permissible.

First consideration should be given to the quality and uniformity of the materials; other factors for consideration are cost, length of haul, accessibility and quantity available. Sources of supply of materials will include commercial gravel, crushed stone or slag plants; commercial mixing plants; natural gravel beds; top soil or clay pits; and, of course, the roadbed itself, which in some cases will supply nearly all of the material desired.

The analysis will show in what ways the material on the road or under consideration is deficient and will also show the amount and quality of materials to be added for proper composition. The determination of required materials is then a problem of computation which is simple to solve.

Thickness and Crown

On an existing gravel road, or other surface which is firm and stable, a thickness of 3 inches compacted is sufficient, but depths of 4 to 6 inches are common, depending mainly upon the character of the subgrade and the weight of traffic. With small sized aggregate, the course should be made thicker than when the mixture is properly balanced:

The usual minimum crown is ½ inch per foot of surface width.

Drainage and Preparation

As in any road, no matter what the type of surface, adequate drainage is a primary factor in stabilized road construction. Proper and sufficient culverts and side ditches are necessary. The subgrade should be built up where the ground water is near the original surface, so that the crown on the road is three or four feet above ground water level. Subdrainage by perforated pipe or tile should be provided in silty or other soils which retain water and swell and heave under frost action.

When using the road-mix method, that is mixing the materials in place on the road, a smooth and compact subgrade is essential. Without a smooth subgrade, it is difficult to mix and place materials, and unless the subgrade is also firm, subgrade soil may be incorporated into the mix.

When the subgrade is firm, smoothing only is necessary, but when it is composed of loose sand, preliminary stabilization will be needed. This may be accomplished by spreading about three inches of soil having a plasticity index of 5 to 15 in a blanket on the surface and then compacting it; or if the soil used for a blanket has a plasticity index greater than 15, it may be mixed by means of blades or harrows so that a plasticity index of between 5 and 15 is obtained.

The subgrade is then shaped and smoothed to the final desired cross section as called for on the plans. It is desirable that it should be somewhat moist.

Using Pre-mixed Materials

The use of pre-mixed materials has many advantages, in that most accurate control of the proportions can be maintained, and thorough mixing is ensured; the clay is properly pulverized. Pioneer Gravel Equipment Co. manufacture a machine for this work. The finished product may be either dry or wet. The dry-mix is hauled to the road, spread by graders, wetted and rolled. This method has several disadvantages, among which are the dust and the possibility of segregation of materials in handling and applying. The wet mix method is to be preferred, the optimum moisture content being about 8%. The product can be spread directly on the road and rolled. Flake calcium chloride can be incorporated into either wet or dry mix; salt is generally used in the wet mix method and as a brine.

The better control of the plant-mix method is only one of the reasons for the present trend toward this method, as it has a number of other advantages which have already been mentioned.

Road Mix Method

Mixing on the road may be accomplished by traveling plant mixers, or by alternately spreading and windrowing the materials by multiple blade maintainers or similar equipment, the methods being similar to those used in other road mix processes.

Calcium chloride may be used as an admixture, that is, added prior to the mixing process and incorporated into the mix during it. It may also be applied to the surface. The integral method is preferred for plant mix and for the road mix method described above. Surface application is preferred for maintenance work, but can also be used for premixed materials. The quantity of calcium chloride recommended for the initial application is ½ pound per square yard per inch depth of wearing course, up to four inches, or 1½ to 2 pounds per square yard.

Salt may be mixed in dry, or as a brine. In the former condition, it can be spread with ordinary disc type of spreader, or by hand. When used as a brine, it is usually mixed 1.4 pounds of salt per gallon of water, a finer screen or size of salt being used than when applied dry.

★ ★ ★

Traffic-Bound Surfaces

There are two ways to place a traffic-bound surface, one the layer method, the other the admixture method. In the former, a layer of definite thickness is placed upon a prepared subgrade, either in a trench and of uniform thickness or with a feather edge. For some time thereafter the surface is loose and ruts readily, so that constant blading is necessary to keep the road in a comfortable riding condition. In dry weather the dust is excessive, and the wind removes a large portion of fines so that consolidation of surface is still further retarded and a rough uneven profile results.

In the second method the usual practice has been to windrow the aggregate at either side of the road and then "feed" it into the road surface by blading after each rain when the surface is softened and when passing traffic will press the thin layer into the surface. Eventually, a crust is formed, of varying thickness according to the character of soil, until no more aggregate can be permanently added, after which further maintenance

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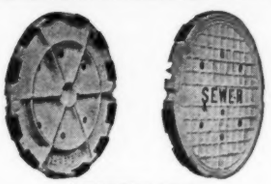

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Hollywood St., Warren, Ohio, Aug. 3, 1936.

After construction of bituminous retread, Aug. 13, 1936.

consists of maintaining a flatting cover some 1½ inches in depth, so as to keep pot-holes filled and provided a fairly smooth riding surface.

Either of the methods provides a surface adequate for traffic not much exceeding fifty vehicles per day at speeds around 30 miles per hour. For greater traffic or higher speeds, they are unsatisfactory as the loss of material during the compaction period is high and almost daily blading or dragging of the road is a necessity. For such conditions, a modified procedure is desirable in order to have an almost immediate consolidation of surface.

With the layer method, this is obtained by a careful proportioning of aggregate and the addition of a sufficient amount of clay to obtain the maximum density by balance between the several constituents; to retain the moisture required to prevent ravelling; and to have enough granular material to prevent rutting. Sand-clay and top soil roads of the South are of this type. Recently, stabilization employing deliquescent salts, such as calcium chloride and sodium chloride, has been developed.

For the admixture method, the procedure is to scarify the existing road surface to a depth of several inches and then mix the aggregate with the soil in proper proportions. In effect, the results are exactly the same as in the layer method, except that the soil is used as a binder instead of the balanced mixture. With a clay soil, scarifying should be to a depth of about three inches and one inch of the soil bladed to one side. The gravel or stone should then be spread, followed by blading and mixing until a uniform distribution has occurred. Two inches of sandy gravel or stone and screenings thus added will produce a layer approximately four inches thick which will have more stability and be more easily maintained than twice as much coarse material placed on the surface.

By this method, it is often possible to use aggregates which otherwise would be unsuitable. For example, cinders by themselves are about as unsatisfactory a surface as can be found, yet when well worked into a mixture with soil, they develop a solid uniform foundation on which thin wearing courses will give good results. Granulated slag, mine tailings and other dump wastes can be used to advantage by this method.

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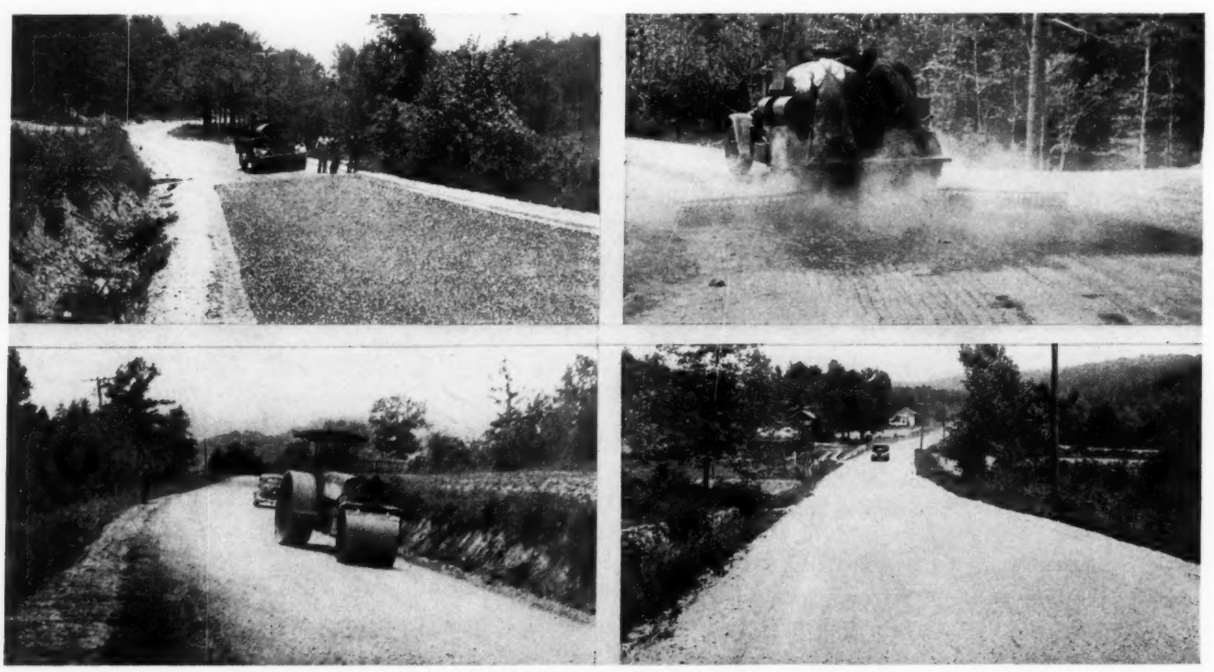

Steps in the construction of low cost roads to serve rural areas and urban citizens. Simple equipment and local materials are employed in construction.

Following is a digest of the important articles published last month having to do with water works design, construction and operation and water purification, arranged in easy reference form.

The Water Wheel

Stuttgart's water supply of 5 mgd. comes, 20% from lakes and 80% from underground and springs, with water from the Neckar river as an emergency supply. The lake water is purified by adding clay and sulphate of alumina to the raw water as it enters a mixing basin. Thence it passes to a preliminary settling tank, and receives a dose of activated carbon as it enters the second basin. It then passes through a rapid filter, and is chlorinated as it enters another tank. From this it passes through granulated carbon filters and then to the clear-water tank. This treatment removes color, bacteria, taste and odor. The river water contains impurities and phenol and grassy tastes, to remove which it is chlorinated, treated with sulphate of alumina, settled, passed through rapid filters, charged with powdered carbon, passed through slow sand filters, chlorinated and dechlorinated. This is said to be the largest German plant using activated carbon for eliminating tastes.[D1]

Hydraulic model studies were conducted on eleven of the dams for the Muskingum (Ohio) water shed project, using the hydraulic laboratory of the Case School of Applied Science. Models were not distorted and included the reservoir approach topography, intake tower and gates, outlet conduits or tunnels, stilling basin, outlet channel, and spillway. From the experience with these models and the structures built as enlargements of them, it was concluded that "the fact that hydraulic models cannot be made to reproduce, in exact miniature, all the phenomena that will occur in the prototype does not detract from their genuine utility. The performance of hydraulic models may be interpreted to great advantage by a designing engineer. It is obvious that certain of the foregoing findings could not be determined over the drafting-board, or by analysis alone, and that other measurements furnish the data for needed analysis. The model studies described in this paper were in the nature of check tests for the sole purpose of expediting the production schedule demanded of the designing staff for this project, by contributing a valuable supplementary method for attacking complex problems of hydraulic design. The tests more than saved their own cost by actually reducing construction expenditure, and, in addition, gave invaluable assurance as to the probable behavior of the finished structures of the Muskingum Water-Shed Project." [K1]

Filter sand ranges in effective size between about 0.40 mm. and 0.55 mm. in present engineering practice, with some indication of a tendency to adopt the coarser sands where permitted by consideration of the various other factors entering into plant design and maintenance. Experimental studies made by the A. S. C. E. Committee on Filtering Materials, cooperated in by plants in 16 cities, indicate that coarser sands produce longer filter runs, produce better "efficiency of wash," and permit greater penetration of floc and thus necessitate a thicker sand layer. Criteria selected for judging the suitability of any particular filter sand were: (1) Its efficiency in removing suspended matter; (2) its ability to pass a large volume of clear water between washes; (3) the ease with which it can be cleaned by the application of wash water. A filter run was considered complete when the loss of head reached 8 ft. at 125 mgd. per acre, or when the effluent turbidity exceeded 0.2 ppm. The shortest runs were those caused by presence of micro-organisms. Conclusions reached tentatively were: A good effluent can be secured with any size of sand, if of proper depth, which should increase with sand size. For sand of uniform size, the critical depth, which is roughly proportional to the square of the diameter of the average size of the sand grains, can be used as a guide. For a graded sand, the depth of a filter bed may be designed correctly if a sieve analysis of the proposed sand and the critical depth of each grade are known ("Critical depth" = the maximum depth to which silt will penetrate into a bed of uniformly graded sand up to a loss of head of 8 ft. when the filter is delivering a clear effluent at a rate of about 125 mgd. per acre). Rate of applying wash water should increase as sand size and water temperature increase; up to 24″ per min. for fine graded sands, and to 30″ for 0.6 mm. sand; and 40″ to 50″ for 0.76 to 1.75 mm. Sizes of 0.5 mm. or less give short runs; 0.6 to 1.0 mm. give satisfactory results; 1.00 to 1.75 mm. give excellent results with adequate depth and rate of wash. Apparently, an ideal filter would be composed of sand of uniform size, which gives greater uniformity in hours of service and in efficiency of wash.[K2]

Filter designing may profitably develop toward "a more nearly balanced design, wherein the basic functions of the filter would be sufficiently improved to enable it to assume a greater share of the purification load at less cost than at present; and in some cases the filter or combination of filters, may in fact constitute the filtration works, with relatively little pre-treatment at all." In one of the London (England) purification works, treatment on slow sand filters is preceded by roughing rapid sand filters without coagulation.[A115]

Coagulation of water at Richmond, Va., using alum decreased in efficiency as the temperature fell, frequently becoming almost a complete failure; while iron salts seem to be ideally suited for cold water coagulation. "Offering much promise is the use of a small quantity of bleaching powder to aid in the oxidation of copperas. . . . If as little as 5% of the necessary chlorine be obtained from the chloride, the improvement is apparent. It is evident that it is quite possible, but now commercially impracticable, to produce the entire reaction of chlorinating the copperas with this calcium compound."[A118]

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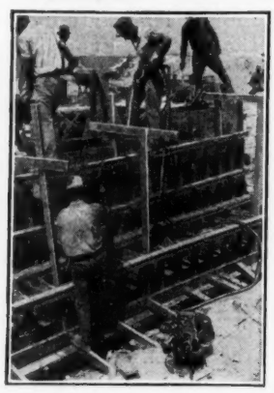

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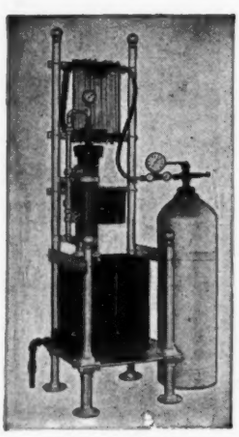

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Copper sulphate is applied to reservoirs by 1—Dragging through the water in sacks drawn behind a boat. 2—At Pasadena solution tanks hang over the side of the boat and water is lifted through them by the velocity of the boat and sprayed over the surface of the reservoir without pumping. 3—At Los Angeles, dry crystals of various sizes are scattered over the water by a power-driven revolving disc, the larger one sinking furthest before dissolving. 4—At San Francisco, a pump draws water from the reservoir and pumps it through an injector throat, through a hole in which fine copper sulphate crystals are sucked and, mingled with the water, are sprayed over the reservoir; dosages up to 1,000 lb. per hour being applied and an area 50′ wide covered from boat or shore. No. 1 is simple and cheap but slow. No. 2 does not require mechanical equipment but the capacity and area covered are limited. No. 3 covers a large area but requires mechanical equipment and the powdered chemical is apt to be blown back into the boat, damaging exposed metal and requiring the operators to wear respirators. No. 4 requires mechanical equipment but covers a wide area and dry chemical does not blow onto the boat.[A109]

Corrosion experiments conducted at Columbus, O., during 1935-36 indicate:

(1) That low alkalinity water containing all or nearly all calcium and magnesium normal carbonates, at a temperature of 150 deg. Fahr., is more corrosive to galvanized metal than water containing no normal carbonates, even though dissolved oxygen is appreciable and some free CO_2 is present.

(2) That normal calcium and magnesium carbonates deposit an uneven scale, from 1/32 to 1/16 of an inch in thickness, which is somewhat adherent, whereas the bicarbonates of calcium and magnesium produce a much thinner scale, probably basic carbonate of zinc, which adheres much better to the metal.

(3) That corrosion of zinc depends more upon the alkalinity of pH of the water than upon the dissolved oxygen present.

(4) That the attack of normal carbonate water on the galvanized tank, which brings about failure, starts at the pin-holes or the weak spots in the galvanizing. The water soon eats its way through such pin-holes and then attacks the iron. These pits keep spreading and growing deeper until the tank fails.

(5) That the products of corrosion, produced by calcium and magnesium bicarbonates, fill the pin-holes, thus acting as a protective film.

These experiments are being continued on a much more elaborate scale.[G38]

Automatic sprinklers discharge about 12 gpm each under 5 lb. pressure, to 58 gpm under 100 lb.; general average pressure should be 12 lb. and 200 gpm discharge. Under reinforced concrete ceilings sprinklers can cover 100 sq. ft. each, or 80 sq. ft. or less for joisted construction. Street main and sprinkler piping should therefore have a capacity of 1 gpm for every 4 or 5 sq. ft. of ceiling area protected without the pressure falling below 10 to 15 lb. at the furthest point.[B13]

Bibliography of Recent Water Works Literature

c, Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

A *Journal, American Water Works Ass'n*
November

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2. The Trend of Customer Accounting Practice. By H. F. Smith, pp. 1677-1685.
3. Reorganization Experiences in Denver, 1933-1936. By E. G. Plowman, pp. 1686-1695.
4. Present Trends Toward Simplification of Rate Case Procedure. By J. Schwartz, pp. 1696-1703.
5. Application of Tabulating Equipment in Accounting Procedure. By F. Twohy, pp. 1704-1711.

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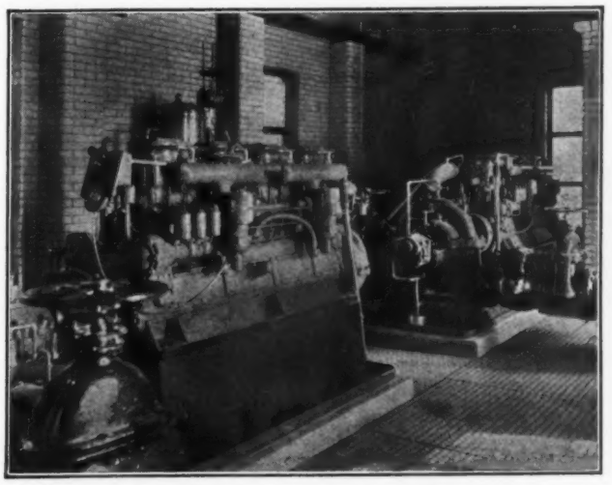

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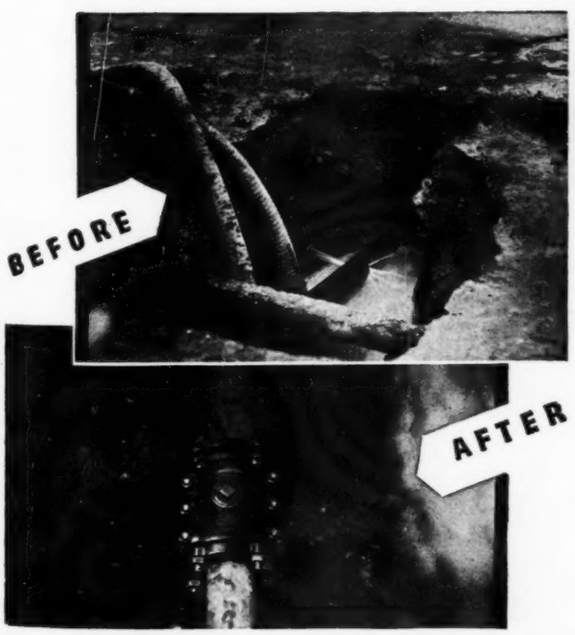

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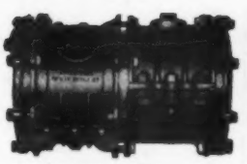
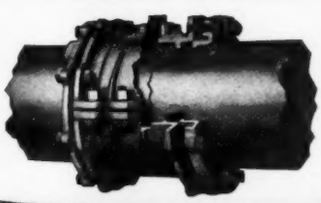


ABOVE—Style 57 Sleeves can be joined in multiple installations of two or more, to cover breaks longer than 8".



ABOVE—Dresser Style 57 Split Sleeve used for repairing breaks in the straight run of the pipe.

LEFT—Cutaway view of a Style 57 Split Sleeve, showing working principle. Once sealed with a Dresser Split Sleeve, the break is sealed permanently.

BELOW—Another style of sleeve—Style 26—encloses split or broken bells.

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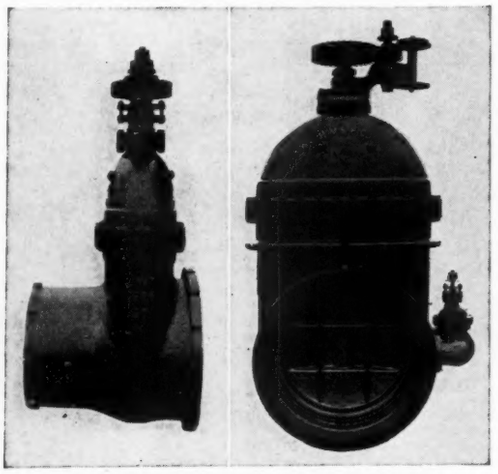

M. & H. geared 20" tapping valve (left) and 30" geared valve with 4" by-pass (right) are for St. Louis water department. M. & H. makes a full line of valves, fire hydrants, etc.

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J *American City*

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L *Civil Engineering*

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P *Public Works*

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3. New Industrial Water Supply System at Birmingham, Ala. By A. C. Decker, pp. 20-22.
4. Suggestions for Designing Swimming Pools, pp. 23-24.
5. New Soft Water Plant for Arcadia, Fla., p. 24.

V *Journal, Maine Water Utilities Ass'n*

December

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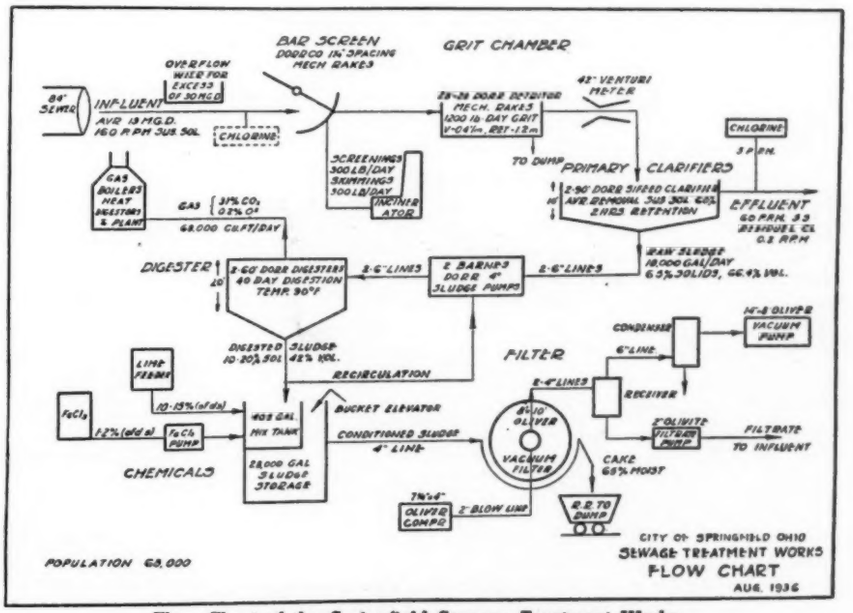
A Digest of the Sewerage Literature of the Month giving the main features of all the important articles published.

The Digestion Tank

Trickling filters grow **molds** when used with certain types of waste waters. *Fusaria* grew so profusely in a filter at the University of Minnesota as to "plug a filter that would otherwise remain open. The growth may cover large areas of the filter, it may plug orifices, pipe lines and pumps. We have encountered these molds when attempting to treat sewage that contained malting plant waste." They are most troublesome in cold weather. Certain species of bacteria which are found in soil parasitize molds, and winter sewage contain fewer of these. Growth of *Fusaria* was checked in this filter by soil inoculation. "Whenever *Fusaria* began to appear, we inoculated the sewage by dumping a pail of soil into the raw sewage for several days in succession. After such inoculations the *Fusaria* disappeared. . . . We are not ready to conclude that the growth of *Fusaria* can be controlled in all types of wastes by soil inoculation, but we certainly did succeed in doing so in the waste which was treated at the Lake Street plant."[C2]

Vacuum filtration of digested primary sludge is practiced at Springfield, O., only, but Columbus plans to do so. After eleven months' operation, filtering over 900 tons (dry basis), tentative conclusions have been reached, including the following: (1) conditioning sludge with ferric chloride alone required 11% ferric chloride and gave an average filtration rate of 6 lb. per sq. ft. per in. By using lime also, the amount of ferric chloride was reduced by 82%, and the combined cost of both this and lime was but about 40% as great; while a filter rate of about 13.5 lb. was maintained. (2) Canton flannel is found cheapest and best filter cover; woolen cost 4 times as much and is attacked by alkaline solutions; 40 oz. canton flannel is used. Clogged covers are replaced by new in 4 hrs. by 4 men. (3) Gas holders or floating covers on digestion tanks should be used, to prevent lowering of gas pressure when removing sludge from tanks. ([4]) An adequate sludge storage tank located between the digesters and the filtering equipment is advocated so as to completely divorce sludge filtering operations from primary sludge pumping; also to concentrate the sludge. (5) Pretreatment with lime does not effect any saving of chemicals and produces sludge that does not filter well. (6) The higher the solids content of the digested sludge, the higher the rate of filtration, with a sharp change between 17% and 19% solids. (7) Completely digested sludges are more amenable to conditioning and filtration than are the semi-digested sludges. (8) Thickening devices or digested sludge storage may be utilized for concentrating digested sludge. (9) Computation of both costs and chemical treatment on both the dry and wet basis is advocated. (10) The lowest chemical cost of treatment is obtained at about 17% solids and a filter rate of about 14 lb. of dry solids per sq. ft. of filter per hr. Drum speeds varied from 50 to 170 sec. per revolution; the higher speeds give much thinner cake but greater production. Covers are changed as soon as the filter rate drops to 10 lb. per sq. ft. "To date our experience indicates that these operations require constant and close supervision of a fairly high type. Generally speaking, I am of the opinion that at present this process should be confined to the larger plants with capacities of 10 mgd and up." The cost for chemicals, labor, filter covers and power gave filtering costs of $2.86 to $3.52 in May, June and July, 1936.[C8]

High-rate filtration is being tested by the Sanitary District of Chicago in an experimental filter 20 ft. diameter containing 8 ft. of stone, 88% of which is 2" to 3½" diameter, the rest smaller. Weak settled sewage is sprayed continuously 23 to 24 hours a day by a Simplex rotary distributor with four arms, 4 flat-spray nozzles to an arm, operated by a head of 2 ft. 9 in. and making 6 to 7½ rpm. From Sept. 1935 to Sept. 1936 the rate was 20.2 mgd; since then, 26.6 mgd. For the first 3½ months air was drawn down through the filter by means of a suction fan at the rate of 1 cu. ft. per min. per sq. ft. filter area, but this forced aeration appeared to have no effect on the effluent and was discontinued. Recirculation of 13 to 15% of the effluent was tested for several months but seemed to be of no appreciable advantage. (Possibly both of these features would be worth while with stronger sewage.) The amount of nitrification was rather slight and there was only a moderate reduction of organic and ammonia nitrogen. The B.O.D. of the final effluent varied from 12 to 44 ppm., averaging 24.3. (An activated sludge



Flow Chart of the Springfield Sewage Treatment Works

unit treating the same sewage gave an effluent averaging 10.4 ppm. B.O.D.) The filter effluent is a substantial improvement over the Imhoff effluent and possibly a little better than that from chemical precipitation. "The high-rate filter functions apparently as a biological flocculator removing colloidal and soluble material in a manner analagous to that of a chemical precipitant. As such a flocculator, it is highly essential that the filter effluent be settled in a secondary settling tank." The year's operation indicates that more or less continuous unloading may be expected at this high rate. There was no pooling and the surface of the filter always had a clean appearance, although covered with a thin film of biological growth.[C3]

Aeration tests in an activated sludge plant at Marlboro, N. J., comparing brush-type mechanical surface aeration and compressed air with spiral circulation, showed that the major divergence between the two was in the distribution of velocities over the tank cross-section. For equal power consumptions, the surface velocity of the brush aerator was 1.77 times as high as that with air at low speeds and 2.5 times as high at high speeds; the bottom velocities also were higher with the brushes but averaged only 1.28 times as high. In both total quantity of D.O. and uniformity of distribution the brushes surpassed the compressed air for equal power consumption. The distribution of the dissolved oxygen in the brush aerator liquid was much more nearly uniform at all points of the tank cross-section. It seems apparent that, for the same power consumption, the quantity of dissolved oxygen in the aerators is closely related to the surface circulation velocity and is more a function of the dissolved oxygen absorbed at the surface than of the oxygen introduced under water by compressed air. With respect to the amount of D. O. supplied to the aerators, the brushes are superior to compressed air, for equal power consumption. With approximately equal purification in the two aerators, the average power consumption during a year's operation was 20.8 hp. per million gallons treated by brushes and 26.2 hp. by air. These figures are based on a higher degree of purification than would often be required. With minimum activated sludge solids and purification these became 12.8 and 15.7 hp. respectively. From the standpoint of operation attention, the brushes require more frequent but less laborious attention than the air tubes. The labor required in operating attendance is about equal for the two. The construction cost of brush mechanism complete at this plant was $6,150 per mg of sewage treated and that of the air mechanism $5,500.

Therefore brush aeration requires less power, costs about the same for construction and attendance, and gives better distribution of D.O. and velocity; but gives a less dense sludge floc (see "The Digestion Tank" for November, page 44), therefore requiring larger settling tanks and digesters.[C5]

Bibliography of Recent Sewerage Literature

c, Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article

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2. Some Fundamental Factors Concerned in the Operation of Trickling Filters. By H. O. Halvorson, G. M. Savage and E. L. Piret, pp. 888-903.
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5. Comparison of Sewage Purification by Compressed Air and Mechanically Aerated Activated Sludge. By G. M. Ridenour and C. N. Henderson, pp. 924-932.
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7. Operation of the Allentown Sewage Treatment Works. By H. J. Krum, pp. 943-965.
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2. *p.* Dispersed and Colloidal Matter in Sewage. By E. V. Mills, pp. 619-622.

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5. West Middlesex Main Drainage, pp. 661-662.
6. *p.* Production of Fertilizer from Sewage Sludge, p. 681.

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7. *p.* Impervious Factors. By F. V. Appleby, pp. 697-699.

E *Engineering News-Record*
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1. *c.* Chicago's Sewer Tunnels, pp. 703-708.
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G *Water Works and Sewerage*
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2. Running an Activated Sludge Plant on D. O. Determinations. By G. Andersen, pp. 418-419.
3. Battle Creek's New Sewage Treatment Plant. By M. G. Damoose, pp. 420-424.
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H *Municipal Sanitation*
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1. New Irondequoit Sewage Plant Put into Service. By K. J. Knapp, pp. 422-424.
2. Operation of Holders for Sewage Gas. By H. W. Alrich, pp. 425-427.
3. Texas Experiment Station Tests Chemical Precipitation, pp. 427, 438.
4. U. S. Agricultural Research Center Operates Novel Sewage Works. by K. K. King, pp. 428-432.
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6. Combined Incineration of Sewage Sludge and Garbage. By M. B. Owen, pp. 433-434.
7. Reducing Cause for Complaint in Disposal of Garbage and Rubbish. By Geo. W. Schusler, p. 434.
8. San Francisco Undertakes Large Sewage Treatment Problem. By J. J. Casey, pp. 435-436, 450.
9. Dangers of Back-Siphonage of Contaminated Air. By R. F. Goudy and N. F. Slane, pp. 437-438.
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11. Testing Sewer Lines for Infiltration. By J. T. Campbell, p. 447.
12. Benefits of Activated Carbon in Sewage. By T. J. Smith, p. 449.

J *American City*
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2. Experience with Sewer Rentals, pp. 57-58.
3. New Intercepting Sewer for La Crosse, Wis., pp. 67-69.

L *Civil Engineering*
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M *Canadian Engineer*
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Flocculation in Theory and Practice

Coagulation of colloids. Action of electrolytes. The iso-electric point.

THE term flocculation means the coagulation and rapid precipitation of finely divided solids, which normally remain in suspension in water or other liquid. In coal washing practice they are often spoken of as slimes or colloids, though the latter term is scarcely correct scientifically.

The term colloid is derived from a Greek word, meaning glue, and can be applied without hesitation to certain substances which diffuse very slowly in water such as gelatine, starch, glue, size, albumen, etc., i.e., non-crystallisable on evaporation. Other substances which are quite insoluble in water can be brought into a colloidal condition by special treatment, such as arsenious sulphide, aluminium hydroxide, copper, gold, and even platinum.

It is evident, therefore, that the colloidal state covers severally totally diverse conditions, and that colloidal gold, and a colloidal solution of glue, have very little in common, except a slow rate of diffusion, e. g., pass completely through filter paper and contain no particles visible to the naked eye or even under a microscope. As glue is a true colloid it would be more accurate to refer to the case of gold in water as a colloidal suspension; a more familiar example is clay, as its apparent solubility in water is well known.

The minute particles of a colloidal suspension are prevented from settling by the bombardment of the molecules of the solvent, and are also prevented from coalescing by the fact that they carry electric charges of the same sign, either negative or positive. Consequently the colloidal state may be defined as a physical condition of matter consisting of at least two parts or phases, one (the disperse phase) being suspended or distributed in the other (the dispersion medium). The particles comprising the disperse phase are extremely minute, so that the force of gravity is counterbalanced by other forces which keep them in suspension. These forces are due to the electrical charge possessed by each particle, which causes it to repel other particles similarly charged, and, as the particles are closely associated, these repelling influences cause the particles to be in a state of constant unordered movement, visible under the microscope, termed the Brownian movement.

This motion is only observable in liquids containing very minute particles in suspension, all the suspended particles having the same electric sign. If particles of opposite sign are introduced into such a liquid, the two groups of oppositely charged particles are rapidly attracted to each other, and as together they are too large to remain in suspension, they gradually settle to the bottom of the vessel. Coagulation of a colloidal substance in this manner must not be confused with chemical precipitation, which is of quite a different nature. The chief distinction between a colloidal solution (or colloidal sol) and an ordinary suspension is that in the latter a settlement or deposition of the suspended particles occurs rapidly, while in a colloidal solution the particles remain indefinitely long in suspension. As regards size of particles, it may be said that those greater than 0.001 mm. form coarse suspensions, those between 0.001 and 0.000001 mm. colloidal solutions and those smaller than 0.000001 mm. molecular solutions. The particles in suspension in a colloidal solution are singularly sensitive to very minute quantities of certain substances, which cause the particles to adhere to each other, or flocculate, forming larger masses which rapidly settle out of a suspension. Sometimes the flocculated particles can be easily broken up and dispersed and a solution re-formed. If the degree of dispersion can be increased or decreased, by reversing the conditions which brought the change the dispersoid is said to be a reversible colloid; otherwise it is termed irreversible.

Peptisation

Peptisation or de-flocculation is of considerable importance, as slight amounts of substances, such as acids and electrolytes, may have, under certain conditions, an adverse effect on flocculation.

When two colloidal sols of opposite electric sign are mixed they mutually precipitate each other, the particles being attracted to one another, and in coalescing form larger masses which settle rapidly. The effect depends greatly on the manner and rate at which the second colloid is added, but if the mixing is effected rapidly it is found that:—

(1) A small proportion of added colloid produces no precipitation.

(2) As the proportion of added colloid is increased the coagulative action is increasingly noticeable, until a proportion is reached which causes immediate precipitation.

(3) A great excess of the added colloid may prevent precipitation.

(4) Mixing two colloids of the same sign does not cause coagulation.

When a substance in solution carries an electric charge it is termed an electrolyte. Acids and bases are electrolytes and so are some salts, also other substances which are ionised in contact with water. In consequence of their electric charges, solutions of electrolytes may cause the coagulation of colloidal sols carrying opposite charges. For this reason, unless special precautions are taken, colloidal sols are seldom very stable, very small amounts of impurity serving to alter their character.

The activity of electrolytes is in proportion to their valency, solutions of salts of trivalent ions carrying three charges having a much greater effect than those of mono- or divalent ions with two charges. Thus it is found that the flocculating power of aluminium cations is greater than barium and magnesium, which in turn are greater than potassium and sodium. The stabilising effect of anions is hydroxyl, sulphate, nitrate and chloride in the order given.

The effect of ions having the same charge as the colloid must not be overlooked, especially when a univalent ion is used for coagulation and another ion of equal or greater valency is present; whereas when a trivalent ion is used, the other ion is usually of less valency, and may have a peptising effect, which upsets all theories based on experiments where this action has been disregarded. The most rapid coagulation occurs when the amount of re-agent added is just enough to ensure complete coagulation, i.e., the iso-electric point. If an excess is added the particles absorb the ions, and the charge on the particles is reversed. Addition of traces of alkali increases the size of positively charged particles and reduces the size of those negatively

charged. The electrolytic coagulation of a colloid composed of particles of various sizes occurs first by the aggregation of small particles with larger ones, and not by the aggregation of particles of equal sizes, i.e., the larger particles act as condensation nuclei of the smaller ones.

There appears to be only a little uniformity in the nature of the charge carried by different substances, e.g., some colloidal metals are positively charged and others negatively. Many metallic hydroxides, however, are negatively, charged, but most sulphides and chlorides are positively charged. Clay is supposed to carry a negative charge, also untreated starch and gum, while colloidal copper, iron, lead and albumen are positive charged.

(Ed. note:—A portion of an article published in *Colliery Engineering*, an English magazine.)

Nevada Highway Department's Laboratory

THE Nevada Department of Highways has recently completed in Carson City and put into service a materials research laboratory, modernistic in design and construction, which provides commodious quarters for testing and analyzing soils, cement and other materials entering into the construction of the State's highways and bridges.

The new structure is a single-story monolithic concrete building, 70 by 40 feet in dimension, earthquake and fire-proof in its design. A special feature of the floor plan consists of a separate shock-proof foundation for a room which contains delicate weighing instruments. Set between the main floor foundation and this "Lab Cell," to absorb any shock or vibration, is a one-half-inch sponge rubber insulator.

Heat will be supplied directly to the building from the present heating plant located in the main headquarters building, although the laboratory will be a separate unit.

A concrete and steel vault in the northeast corner will be used for storing departmental records.

State funds for the construction were supplemented by a substantial grant of ERA money, and work was carried on under PWA supervision. The total cost of the structure and equipment was $38,000. Work was started under contract during February of this year, and the building is now ready for occupancy.

Among the many new instruments and testing apparatus installed are included:

A modern 200,000-pound Universal testing machine equipped to accommodate 6 by 12 inch and 8 by 16 inch concrete cylinders for determining compressive strength, as well as for testing steel. This machine has been set on a concrete foundation in a pit near the center of the building.

For the making of sensitive chemical analyses and physical tests a keyboard-type analytical balance will be used, capable of differentiating weights down to one twenty-thousandths of a gram.

A Universal type microscope will be used in examining minerals, steel and other metallic sections. Specimens or "plates" are ground to a fineness of thin paper, put under the "glass" and checked by the operating technicians for granular structure and cohesive qualities. If there are any defects or weak spots in the materials this instrument shows them up. An accurate measure is thus obtained for a set standard in road-building materials.

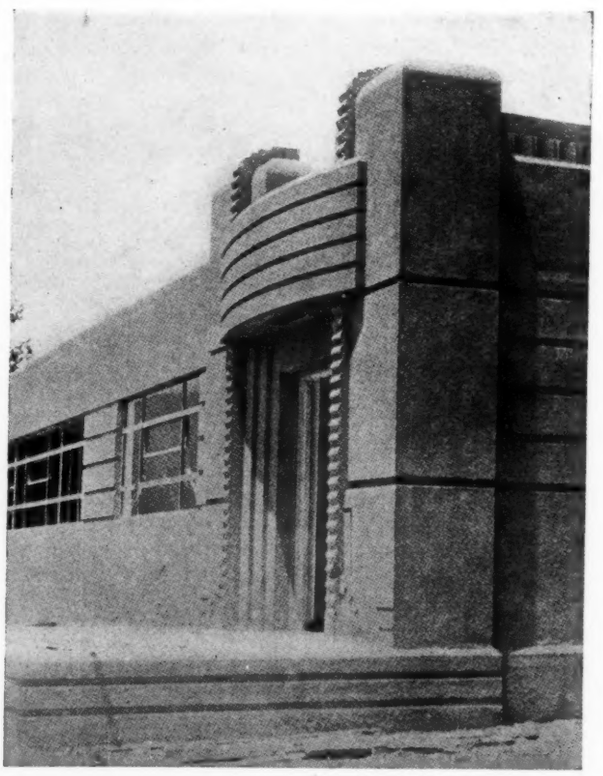
A carbon combustion train has been installed to determine carbon content in steel.

A "centrifuge" will be used to determine the "centrifuge moisture equivalent of sub-grade soils"; in other words, the moisture-absorbing qualities of soils found along proposed highway routes. In this connection it might be interesting to observe that the State Department of Highways gathers hundreds of samples of subsurface soils at numerous places along a right of way. These samples are analyzed, tested, and checked by the laboratory operators to determine whether the soils contain ingredients harmful to certain road-making materials. Particularly does this apply to metal pipes used in the construction of culverts for water drainage. If harmful substances are found to exist in the soils, specifications are changed to meet the unusual conditions. Materials which offer greater resistance to these inclusions are then utilized.

An electrical mixer for analysis of soil (commonly referred to as the "milk shaker"), provides a method for determining the approximate quantities of silt and clay present.

Of special importance to the department will be two transverse beam testing machines for determining the flexural strength of concrete.

Apparatus for testing oils, asphalt and other road-surfacing materials and other items in the present testing room will be installed in the new laboratory.



A corner of the new materials research laboratory of the Nevada Dept. of Highways

Federal Appropriations for Flood Control

One of the important contributions to the soil conservation activities of the Federal Work Program has been the flood control work supervised by the U. S. Army Corps of Engineers, under which the Federal government aims to remove the flood menace from cities and towns along the banks of rivers subject to spring floods. The President made an orginal allocation of $5,500,000 for surveys by the Army engineers so that work could be started as soon as possible with appropriations Congress is expected to make next spring under the Omnibus Flood Control Bill.

Up to December 1st, $604,580 had been spent in making surveys of the Susquehanna river, reservoirs at its headwaters and on the West Branch of Delaware river and in the Upper Finger Lakes area; of a reservoir system for Pittsburgh and the upper Ohio river, and one for the Connecticut river; of the Potomac river near Cumberland, Md., and of the Conemaugh river near Johnstown.

Construction work has been done totaling $2,689,331 on Federal flood control projects and $419,490 on non-Federal projects, including those for Los Angeles flood control; Susquehanna river at or near Kingston and Edwardsville, Wilkes-Barre and Hanover, Hornell, Painted Post, and Lisle; Hoosic river near Hoosic Falls and Bennington; Anacostia river; Otter creek near Rutland, Vt.; Connecticut river at Hadley, Hatfield, Springfield, West Springfield and Hartford; Monongahela river at Elizabeth; Alleghany river at Manorville and in Armstrong county; Nashua river at Fitchburg; Merrimac river at Haverhill; and channel clearing at Oxford and Avoca, N. Y. The allotments for these were $11,520,786, of which $3,108,821 had been spent by December 1st.

Highway Lighting in Ohio

The Ohio State Safety Council on December 5th dedicated a one-mile section of Route 2, outside Sandusky as a "safety educational highway," the third to be completed. The aim is to provide 48 such highways distributed over the state. The safety features include a smooth, 3-lane stretch of new concrete, widened shoulders, and a high-visibility lighting system. Roadway signs giving concise safety messages are installed along the highway, and a State highway patrol polices the road. The lighting system consists of twenty-four 10,000-lumen General Electric sodium lights, set about 200 ft. apart on alternate sides of the road.

Colored Aggregate for Concrete

Laboratory research and investigation have resulted in making commercially available highly colored aggregates in which the color is a product of the internal fusion or vitrification of the coloring component with a stable base and is as unchangeable as it is in mosaic tile, fine porcelain or cathedral glass. There are two types of such aggregates—ceramic and vitreous. The former is made from clays and other ceramic raw material by processes similar to those used in producing pottery and china ware. While the colors are bright and clear, they are characteristically soft. The vitreous aggregates are made with materials and by methods similar to those used in producing porcelain or glass. These are distinguished by their luster and brilliance. Certain colors can be produced only with this type. A practical technique has been developed for using these colored aggregates in concrete through the medium of cast stone, the aggregate particles being set en masse through the medium of cast stone instead of singly as in mosaic.

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Lubricating Deep Well Pumps

Characteristics of suitable lubricants and how to apply them.

DEEP well pumping is, in the majority of cases, done with turbine pumps, driven by electric motors in most cases, although internal combustion engines are sometimes installed. Whatever the motive power, it is located on the surface and offers no special lubricating problem. The pump, however, is some distance—hundreds of feet in some cases—below ground and accessible only by raising it from the well; it requires lubrication as much as any other kind of turbine equipment, but whether it is receiving it cannot be learned by observation. It is therefore all the more desirable that every care be taken to provide the best lubricant, applied in the most effective way.

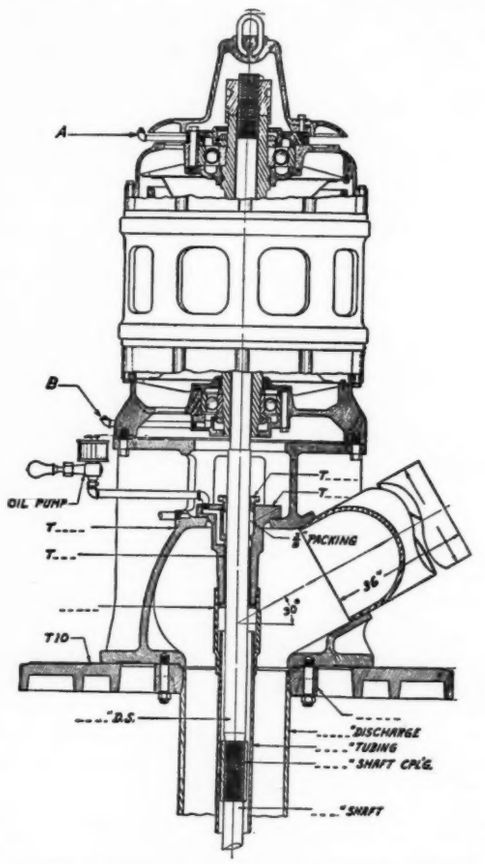
In some pumps water only is used as a lubricant, and assurance must be had that water will be supplied to all bearings at all times—when the pump starts before any water is flowing up the pipe, or in case hard pumping causes it to suck air temporarily. Also that the water is free from sand or other foreign matters.

When oil is used, it should be of such quality as to maintain the requisite lubricating film, have as little tendency as possible to run out from between the shaft and its casing or protecting pipe at the bottom of the pump, and show as little internal friction as possible. The Texas Company, in its monthly publication "Lubrication," gives the following advice:

Where lubrication by means of fluid oil is practicable, it will usually be best to use a comparatively low-viscosity product due to the high speeds involved. In general, a viscosity of from 100 to 200 seconds Saybolt at 100 degrees Fahr., will serve the purpose, provided that the stuffing box in the bottom of the cover pipe gives the requisite seal. An oil within this viscosity range would also be adaptable to lubrication of electric motor bearings. This would be an advantage, of course, for it would enable the use of one oil throughout the entire mechanism.

On the other hand, one must always consider the operating temperature range before making final decision as to the viscosity which will be most conducive to positive lubrication and minimum power consumption. This latter can be markedly affected by using too heavy an oil, as practical tests have indicated. The normal temperature of well water will be between 50 and 60 degrees Fahr.; seldom will it exceed 65 degrees Fahr., or be lower than 45 degrees Fahr. One should, therefore, study the viscosity of any lubricating oil intended for deep well pump lubrication at this operating range; obviously it will appear to be comparatively high. For example, an oil having an observed viscosity of 200 seconds Saybolt Universal at 100 degrees Fahr., will be between 1500 and 2000 seconds Saybolt at 45 degrees Fahr. It is evident that the use of too heavy an oil will involve considerable internal friction within the oil itself. Furthermore, if the oil is too heavy, it may not be able to pass through the bearing clearances fast enough to maintain proper lubrication. To some extent this would lead to increased temperature, which, of course, would tend to cause reduction in viscosity of the oil. On the other hand, there might also be an increase in power consumption which would be entirely unwarranted.

Under conditions of a marked difference in head, however, (especially where automatic circulation of the oil is not provided for) the oil might exert a pressure on the openings around the bottom bearings so much greater than would the water in the well (particularly when the pump is not operating) that this oil would run out at the bottom between the shaft and cover pipe, if the stuffing box happened to be worn to any extent. This occurrence will be indicated by excessive consumption of lubricant. On some types of pumps loss of oil can be prevented by controlling the rate of oil drip at the sight feed valves. On others it may be necessary to use a light grease which will be capable of giving adequate lubrication with as low a drag as possible and yet have sufficient body to resist the unbalanced pressure which may be involved. As wear on the stuffing box increases, it may be necessary to use a heavier grade of grease, though of course this may involve the sacrifice of a certain amount of mechanical efficiency. Such a grease should have a consistency very nearly the same as that of vaseline, and should be a product which will retain its plasticity at the approximate temperatures of pumping.



Section of a Layne Type TI-7 pump head showing oil pump for shaft bearings, and at A and B the lubricator extensions for serving the ball bearings of the electric motor.

The adaptation of automatic balanced circulation lubrication, whereby oil is fed from a surface tank so located that oil and water pressures will be equalized, is claimed to eliminate the possibility of waste and contamination of the well water. This oil is pumped through the bearings and back via a return pipe, by a suitable lubricant pump. Such a system makes possible the con-

tinued usage of a fluid lubricant capable of giving the desired results with the least development of internal friction. Of course it requires the use of a suitable cover pipe, within which the shaft and steady bearings are located. Here, the problem is much the same as involved with a turbine, excepting that the temperatures are lower. Therefore, oils of approximately the same viscosity as mentioned above should function satisfactorily.

Continuous circulation of oil under definitely controlled pressure affords a very practical and economical way of obtaining automatic lubrication with a minimum of labor and attention. As a rule, a considerably greater volume of oil will be handled in a circulating system than where a unit type lubricator is used. Direct pressure circulation of an excess of oil is admirable for lubricating bearings where suitable means is installed to completely control the path the oil follows. Lubrication by pressure circulation is also advantageous in that it provides for sufficient settling of the oil to insure precipitation of the greater part of any foreign matter that may have been picked up by the oil in passage through the bearings. Furthermore, since these are flood lubricated, they will be cooled as well as washed free from accumulations of foreign matter unless the latter is of a gummy nature resulting from the use of improperly refined oils. On the other hand, water cooling coils are sometimes installed to take away the heat acquired by the oil during circulation. By careful study of inlet and outlet temperatures of oil and water, and the use of coils of adequate capacity, accurate control of the inlet oil temperatures can be maintained.

Water Services in Minnesota Cities

In response to a questionnaire sent by the League of Minnesota Municipalities and Municipal Reference Bureau to the 70 cities of that State of between 2,500 and 25,000 population, 46 answered the question: "What is the regulation or practice as to the kind of service pipes?" Of these, 16 required the exclusive use of copper pipes, 2 of lead pipe, and 5 of either copper or lead. Four cities which allow the use of galvanized iron stipulate that lead must be used under pavement.

In 24 cities all meters are owned by the city, in 25 are privately owned, and in one, part are privately and part city-owned.

In 11 of the cities the meter is city-owned, but all other cost of making the installation is at the applicant's expense. In 17 cities all cost, including the meter is borne by the applicant.

Twenty-eight cities require installation of services to vacant lots prior to paving of the street. Nine of these require the owners to pay the cost of this, the other did not give information on this point.

North Toronto Sewage Disposal Plant

This plant, capacity 10 mgd, is of the activated sludge—sludge digestion type. Activated sludge is mixed with incoming sewage in a mixing channel, where the mixture is agitated with compressed air supplied through diffuser plates.

Excess gas from the digesters that is not used in heating the tanks is burned in a gas incinerator where screenings from the racks also are burned.

The sludge-beds are glass-covered, and the enclosures are provided with unit heaters and fans to supply heat and assist ventilation.

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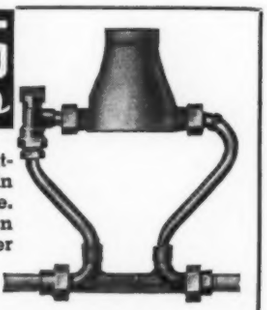

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Economic Considerations in Treatment of Industrial Wastes*

By MAJOR MICHAEL J. BLEW

OF the various classes of industrial wastes, liquid wastes or liquid-carried wastes are the most difficult to dispose of properly, and the term "industrial effluents" is much to be preferred to "industrial wastes" for describing matters which pollute streams and other bodies of water.

Industrial effluents may be classified in various ways. One of these is according to the best methods for treating them, there being three general classifications: *First,* those that can be treated principally by sedimentation, either with or without the use of coagulants, being those which carry solids in suspension such as coal culm, china clay, and debris from lens grinding and stone cutting, but carry in solution no solids of a polluting nature. *Second,* effluents that can be treated primarily by sedimentation, possibly with the use of coagulants, followed by some secondary treatment; containing considerable solids in suspension and also soluble solids of a polluting nature. Tanneries, glue factories, wool scouring, paper plants, beet sugar plants, etc. belong in this class. *Third,* effluents that are not improved to any great extent by plain sedimentation and must be treated by chemical or biological methods. These wastes contain solids in solution and colloidal dispersion. By-products — coke-oven and gas-house wastes, chemical effluents, pickling liquor, dye water, dairy and milk products belong in this class.

From point of view of cost, different trade effluents have available differing possibilities in the way of treatment. Some can be treated at an actual profit by recovering by-products; others treated to recover sufficient revenue to cover the cost of treatment, or to defray only a fraction of the cost of treatment, or possibly at a complete loss. Success in prevailing on industries to install treatment plants varies directly with the ability of the industry to recover revenue from the process.

A few cases where industries have profited directly by measures to alleviate stream pollution are given below.

Paper industries, by installing save-alls and recirculating the white water, have been able to reduce the pulp loss to practically nothing. The higher the grade of the paper stock being produced, the greater the loss that may be encountered in the process when only a few ppm of pulp are permitted to escape. The value ranges from $20 to $65 per ton of pulp, practically all of which can be recovered by recirculating the white water. In this instance success was achieved by chlorine or chlorine-ammonia treatment of the white water to prevent the development of fungus growths. This can be operated on practically a closed basis with a saving of pulp and power and reduce the pollution load about 70% to 90%.

Photographic film manufacturing produces a waste containing as much as 3 ounces of silver per ton of waste water. This can be recovered by zinc oxide and lime, making the process profitable. One instance on record shows a bathing beach contaminated with such a waste, while the river mud near the outlet from the plant assayed $170 of silver a ton—richer than many silver ores. A settling tank with baffles can recover most of the silver residues.

Mercerizing plant waste contains caustic soda, 97% of which is being recovered by a process by which many similar wastes could be treated with a saving of chemicals and tremendous benefit to the rivers, and at a profit.

Curled hair is being recovered by one company, by use of a screen and settling tank, in sufficient amount to make the process profitable.

A chemical plant was located in the basin of an old quarry where considerable spring water, seeping from the rock at the rear of the plant, ran through the company's grounds, picking up in its travel some concentrated chemical compounds which caused a taste in the water suppy of cities many miles down stream. By collecting this water before it was polluted and storing it behind a simple earth dam the company was able to use it for boiler and cooling water at a saving of about $3,000 annually, the excess water being conducted around the premises.

A *wool scouring* plant installed a semi-closed system to utilize the water from the end of the scouring train after treatment by centrifugals. The effluent was reduced 90% in volume and in pollution load, and the water consumption was reduced to about 10% to 15% of the original, this amount being necessary to compensate for loss by steam and spillage and as make-up water to maintain the dissolved solids in proper balance. By treating the sludge, grease was recovered worth 6 to 7 cts per pound, making the process self-supporting. (In Germany, such sludge is filtered and the cake treated with benzine.) There was saving in fuel for heating the scouring water, in soap and detergents, in water pumping charges and in stock losses through the effluent. Wool scoured in this way is said to have a softer, finer texture than that scoured in the usual manner.

A *grease rendering* plant, by cooling its waste liquids and skimming them, recovered 60% to 70% of the grease—sufficient to pay for the treatment and render the effluent to the sewer unobjectionable.

A *laundry* by installing a trap and screen recovered enough linen to pay for the process, and produced an effluent which was treated with the domestic sewage without difficulty. There are instances where sufficient linens (largely from hotels and restaurants) are recovered on the screens of disposal plants to warrant the conducting of sales.

Distillery slop pollution may be avoided almost entirely by evaporating the slop; the entire solid content being recovered for cattle food and the water vapor from the evaporators being returned to the mash tanks.

A *carbonizing plant* was added by a wool scouring plant and the effluents from the two processes were combined and trapped, skimmed and screened and sufficient wool recovered to make it profitable. The effluent was

* Extracts from a paper before the American Chemical Society, Section on Water, Sewage and Sanitation.

alkaline and sufficiently cleaned to mix with domestic sewage in the sewerage system.

Meat packers, in one case, have an arrangement to sell dried blood and grease from their plants to another which is profitably engaged in making glycerine and stearic acid.

A *storage battery* and a *silk dyeing* plant, located near each other, the former producing a strong acid waste and the latter an alkaline one, both deleterious to the sewer structure and to sewage treatment, combined their effluents and mixed them with the domestic sewage with no ill effects.

Apparently the proper plan of attack is (1) to increase the development and installation of closed systems, which can be used by many plants that at present decry the idea. (2) To develop new and better processes of manufacture. (3) To institute intelligent research on the utilization of by-products. (4) To separate waste from drainage and storm water to reduce the cost of effluent treatment. (5) To combine wastes, taking advantage of their differences in chemical character to render them innocuous or minimize their deleterious and destructive effects. (6) To utilize heat in effluents by means of heat exchangers. (7) To develop better machinery. (8) To utilize cheaper construction in plant design.

In connection with (8), there is probably no reason for the construction of elaborate concrete tanks when steel can be utilized to better advantage and for much less cost. Steel has been used in water works for years with success and undoubtedly can be used in sewage and trade waste work with equal success. The present method of construction, erection and welding in place makes steel a desirable material for treatment tanks.

Liquid Wastes Contributed by Industries

IN order to determine the volume, strength and character of the industrial wastes discharged into the streams and watercourses of New Jersey, and their relative importance in comparison with domestic wastes. and to obtain general information regarding the possibilities and difficulties encountered in the treatment of these wastes, a survey was conducted by the State Agricultural Experiment Station with the aid of a number of chemists and engineers employed under the CWA and ERA. A Bulletin has just been issued by the Station giving the results of this investigation, from which the following brief abstract has been prepared. (Bulletin 610, "Industrial Wastes in New Jersey," by Willem Rudolfs and Lloyd R. Setter).

The sewage of about 1,000,000 persons is discharged untreated into the watercourses, that of 2,200,000 is partially or completely treated, and about 800,000 dispose of their household wastes in cesspools, septic tanks, on land, etc. About 100,000,000 lbs. of dry solids originating in sewage reach the streams in a year. The survey indicated that the industries contributed about 80% as much solid matter.

There were 1966 major industries producing liquid wastes, of which 754 were silk; 427 were power laundries, dyeing and cleaning; 265 chemicals, grease, soap, fertilizers, paints, dyes; 153 dyeing and finishing textiles, and the remainder were leather tanning and fur dressing, canning, oil, petroleum, gas, paper and wood pulp, rubber and waste, and slaughter house and meat packing. Of these, 1792 were visited and definite waste information was obtained from 1213. Since many industries were duplicated, samples of 401 were obtained, 251 of which were completely analyzed and 150 partly analyzed for confirmation. These 401 consumed an average of 54,640,000 gal. of water daily and discharged 43,561,500 gal. of liquid wastes.

The chemical analyses made consisted of total solids, ash of total solids, suspended solids and their ash, settleable solids and their ash, volume of settleable solids (sludge), soluble solids and their ash, total non-settleable suspended solids and their ash, oxygen consumed (30 min. at 100° C), acidity and alkalinity to phenolphtalein and methyl orange, chlorides, and pH. Special or more complete analyses were made on certain types of waste samples.

The results of the analyses are given in the Bulletin in the form of tables, which are too voluminous to give in this abstract. In general, it was learned that, while about half of the sewage solids are capable of rapid settling and may cause sludge bank formation, the settleable sludge from industrial wastes is only about 20% as great, or 25% per unit volume of solids. In oxygen consumed, however, the estimated population equivalents amount to over 3,000,000, or two-thirds of the total domestic waste discharged by the entire population of the State.

Calculation was made of the oxygen demand and and suspended solids of the waste products of each industry per employee of that industry. This showed the oxygen demand varying from a population equivalent of 470.0 per employee for distilleries to 2.9 for organic industries (meat packing, rubber, fish, tallow, wool and rug, acids and salts); and the suspended solids varied from a population equivalent per employee of 181.0 for distilleries to 2.4 for organic. The tabulation of these results is given herewith. If we can assume a similar output per employee in other localities, the oxygen demand and suspended solids from industry in any such locality can be approximated by multiplying by the figures in this table the number of employees in the several industries of the locality. (The average per capita oxygen consumed value was taken as 0.068 pounds per day).

Oxygen Demand and Suspended Solids of Waste Produced per Employee of Each Industry on Basis of Domestic Sewage

(Domestic Sewage = 1)

Industry	*Oxygen Demand*	*Suspended Solids*
Tannery	25.3	12.0
Chemical manufacturing	22.5	7.4
Organic	2.9	2.4
Steel pickling	3.6	3.8
Dye	44.2	5.4
Laundry	22.8	22.2
Distillery	470.0	181.0
Dairy	44.6	5.7
Miscellaneous	13.2	6.8

The different groups of wastes included the following types of discharges: laundry: general, rinse, suds, wash, bleach; dairy: general, can, whey, tank, bottle, washings, ice cream, powdered milk; dye: general spent-blue-, black dye, bleach, textile sizing, acids and alkali solutions; distillery: yeast and malt slop; tannery: general, pigments spent, tanning extract, cleaning and coloring solutions, soap, lime, alkaline, acid, and chrome liquor wastes, general skin and leather treatment wastes; steel pickling: general steel plating, refining, polishing, and solvents wastes; organic: meat packing, rubber, fish, tallow, wool and rug, acids and salts; chemical manufacturing: general, coloring and dye, resins, soaps, inks, solvents.

Treating Industrial Wastes in Wisconsin

THE Wisconsin Bureau of Sanitary Engineering has been investigating from 250 to 317 industrial waste problems each year for some years back. Among the outstanding developments from these investigations, as described in their latest report, are the following.

Malt House Wastes

Relatively little information being available on the utilization or treatment of malt house wastes, arrangements were made, with the cooperation of the officials of the firm operating a malting plant at Jefferson Junction, to establish a testing station to try out proposed methods for removal of pollutional substances in the wastes. An experimental plant was built and operated by the company during the summer and fall months of 1934 under the supervision of this Bureau.

Operation of the experimental plant covered the period from warm summer weather through freezing winter conditions existing during the early part of December. Results of studies made are summarized as follows:

1. An average of 80 gallons of wastes requiring treatment are produced per bushel of barley processed per day, such wastes having an average 5-day biochemical oxygen demand of 400 parts per million.

2. A reduction in the pollutional strength of the wastes of 90% or more as measured by the oxygen demand can be accomplished by fine screening and treatment by a trickling filter from 6 to 8 feet in depth with a capacity of 50 cubic feet of crushed rock per pound of 5-day biochemical oxygen demand applied to the filter per day.

3. The temperature of the waste is sufficiently high to make housing of the filter unnecessary for satisfactory treatment results during winter operation.

4. A 40-mesh screen will remove most of the waste grain and sprouts from the waste, the use of a rotary screen with a needle spray or mechanical facilities for cleaning of the wires being considered essential.

From a study of the character of the wastes and from preliminary small-scale aeration tests made in the state laboratory of Hygiene, it is believed that effective treatment of the malt house wastes might be secured by use of the activated sludge process.

Based upon these studies, a full scale plant was designed and built at Jefferson Junction during 1935. The plant includes a 40-mesh rotary screen unit; a trickling filter 8′ deep, built of crushed limestone enclosed by a filter wall of concrete slabs formed with openings for adequate ventilation, and equipped with a rotary distributor; and a settling tank provided with mechanical sludge collectors of the straight-line flow type. The sludge is disposed of as fertilizer or fill material. The system was placed in operation during the fall and apparently is giving satisfactory results, even with subzero temperatures. This tends to confirm observations made during the experimental work. Further tests are to be made to more definitely establish the effectiveness of treatment.

Cannery Wastes

A development of interest in two of the chemical treatment plants built by canneries during 1934 has been the use of welded steel tanks with essential equipment manufactured in Milwaukee and furnished as a complete unit for installation in place of the usual reinforced concrete tanks. The use of these steel fabricated tanks is reported to appreciably lower the initial cost of the system, and from observations and tests made during the past canning season, will give as effective treatment results as plants of the type previously installed.

Tests were conducted at a canning plant that recently installed a continuous-flow type chemical precipitation system provided with mechanical facilities for sludge collection and removal. The results indicated effective treatment but no increase in efficiency over the fill-and-draw process used in all of the plants installed during recent years in Wisconsin.

Where essential, additional treatment for the effluents from these plants has been provided through municipal sewerage systems. Special studies have shown that trickling filters would provide a high degree of treatment for the canning wastes, providing they were not overloaded.

Special studies have been conducted by this Bureau at Fort Atkinson to determine the feasibility of using the activated sludge treatment process in removing or modifying pollutional substances from pea and corn canning wastes, after preliminary screening and mixing with the domestic sewage. While the pea canning operations extended over a relatively short period during the 1934 pack, data obtained were sufficient to indicate that an excessive load was being placed on the sewage treatment works and that additional aeration or pre-treatment facilities for the cannery wastes would be essential for satisfactory results. Data obtained during the corn canning season further substantiated initial results. When the loading of the sewage works was such as to increase the sludge index (Mohlman index) above 200, the oxygen content of the effluent decreased and bulking and other operating difficulties were encountered. Studies of the batch digestion of mixtures of cannery waste solids and equal portions of raw and activated sludge in carboys, suitably equipped for measurement of gas and sampling of sludge, indicated that, up to 20% by weight of pea cannery solids, there was very little change in the digestion characteristics, but with an increase of the cannery solids above 20%, there was an increase in acidity during the early period of digestion and in the per cent of carbon dioxide in the gas produced.

Kraut canning waste treatment control procedures have been established, tests showing that by fine screening, chemical precipitation with 3 to 5 pounds of alum and 35 to 40 pounds of lime per 1000 gallons, sand filtration and chlorination of the filter effluent with an average of ¼ pound of chlorine per 1000 gallons over all efficiencies of 76% to 96% (average 89%) removal of pollutional substances as measured by the oxygen demand can be accomplished. With proper control of treatment and with improved facilities to secure distribution of the wastes on the sand filter, it is expected that efficiences of 90% or better can be continuously maintained.

Milk Plant Wastes

Based upon experimental work conducted at DeForest, Wis., during the period 1927-1930, and other studies, biological filter systems are being installed in the solution of nuisance and pollution problems caused by the milk plant wastes.

Utilization of whey from cheese factories in the

manufacture of food or other products, particularly for those situations where such wastes offer disposal difficulties, needs to be given further study. By suitable recovery methods it is very probable that practical and profitable solutions can be developed for existing whey disposal problems.

Pulp and Paper Mill Wastes

The outstanding development in the waste utilization and stream improvement activities being carried out with the aid of the Wisconsin Pulp & Paper Industry, was the installation of the Howard Process for reclaiming pollutional substances in sulphite waste liquor on a mill-scale basis. Pilot plant tests indicated that the process has an efficiency of 75% or better in the reduction of high oxygen demands characteristic of this waste.

Surveys of whitewater systems and other mill wastes indicated further progress in reducing fiber losses below 1% and volumes of water below 20,000 gallons per ton of product. Results of this survey indicate that fibrous wastes from the industry are becoming less and less important a factor in stream pollution, due primarily to the steps taken in the individual mills in "bottling up" and re-using much of the fiber-bearing water formerly wasted.

Other activities in connection with pulp and paper mill wastes have included studies on the effect of paper fiber on the digestion of domestic sewage solids and the effect of black liquor from the sulphate or kraft pulp process on the treatment of domestic sewage by chemical precipitation.

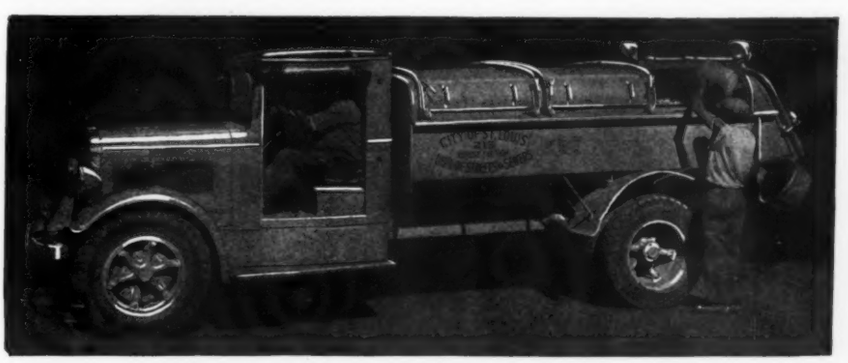
Tannery Wastes

During the early part of 1935 there were placed in operation two clarifiers for tannery wastes as an addition to an existing separate sludge digestion plant for municipal sewage at Fond du Lac. The sludge removed from the tannery wastes was first disposed of by lagooning. Eventually this procedure will need to be discontinued, with development of other methods of disposal. Studies previously conducted by this Bureau having indicated that up to 40% by weight of the tannery sludge in a mixture with domestic sewage sludge could be digested, provision has been made for pumping the tannery wastes into the two existing digesters. Aside from some foaming during the first two weeks no significant change has occurred in digestion conditions.

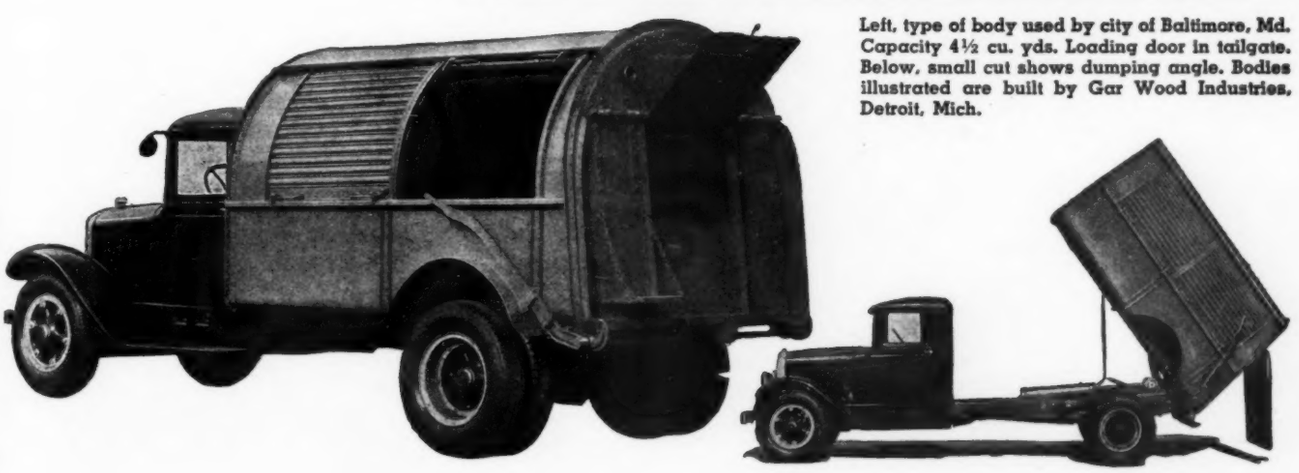
It is not anticipated that any serious difficulty will be encountered so long as the tannery sludge remains substantially below the indicated 40% tannery-sewage sludge limits. Since 1932 another plant, equipped with separate sludge digestion facilities, has been satisfactorily taking care of relatively small amounts of tannery solids in combination with the sewage sludge. The tannery wastes in this situation are given preliminary treatment through a No. 20-mesh rotary screen unit to remove hair and fleshings prior to joining these wastes with the sewage at the inlet of the primary clarifier at the municipal plant.

With the renewed interest in chemical precipitation for municipal sewage treatment, and with successful sludge disposal by filtration and incineration, it is possible that a number of the larger industrial cities will be in a better position to cope with sewages containing fluctuating amounts of trade wastes known to be inimical to biochemical treatment processes. Chemical precipitation methods should also prove particularly helpful in taking care of problems created by seasonal industries.

Modern Garbage Collection Units

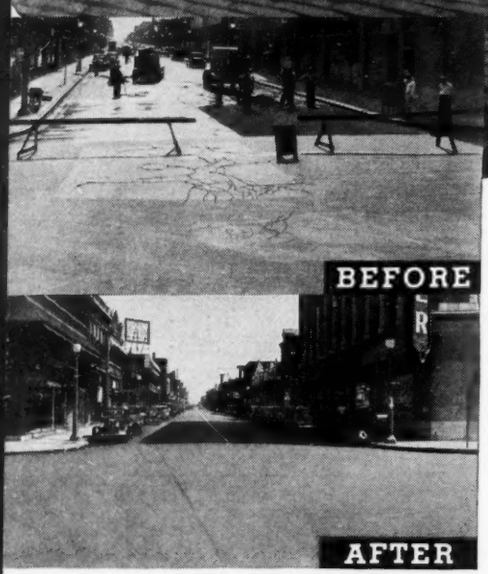


At the right, a fully enclosed garbage body with sliding steel covers on steel rollers. Tailgate is water tight. Capacity 4½ cu. yds. Floor of body slopes to rear. Used by city of St. Louis, Mo.

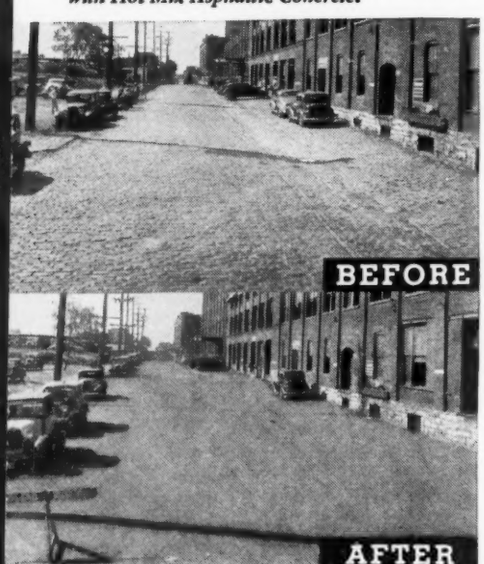


Left, type of body used by city of Baltimore, Md. Capacity 4½ cu. yds. Loading door in tailgate. Below, small cut shows dumping angle. Bodies illustrated are built by Gar Wood Industries, Detroit, Mich.

Clark Avenue, looking toward 14th Street. Old granite blocks re-surfaced with Hot Mix Asphaltic Concrete



Locust Street from Leonard Avenue. Re-surfaced with Hot Mix Asphaltic Concrete.



Eighth St. looking toward Chouteau Ave. Very rough granite block covered with Hot Mix Asphaltic Concrete using a minimum of ¾" thickness.

How St. Louis re-surfaced 85 miles of streets with ASPHALT at LOW COST

A total of 1,800,000 square yards of pavement has been re-surfaced in St. Louis during the past three years with *asphalt*. That's equivalent to 85 miles of street with a 36-foot width.

In carrying out this re-surfacing program, the engineers had to consider several essential factors. First—*Economy,* due to a limited budget and the large amount of re-surfacing involved. Second—*Safety,* by providing a non-skid, non-glare surface. Third—*Durability,* under heavy traffic demands. And fourth—*Quick Application,* to avoid interference with traffic.

The Standard Oil Company (Indiana) which furnished most of the asphalt for this work, is, of course, pleased that the St. Louis Engineers approved its material and found it satisfactory in all respects.

Here is dramatic proof of the adaptability of asphalt—proof of its economy, safety, durability and quick application possibilities! Let a representative from *your* local Standard Oil office talk over *your* paving problems with you. This service is without obligation or cost—yours for the asking—and it may very readily be an economical solution to all your paving needs. Phone at any time. Take advantage of Standard's long years of experience in every kind of paving problem.

Here's What Happened in St. Louis

A large amount of re-surfacing was placed over sheet asphalt. A special mix was used, consisting of a hot mix at 250° F. using 95% Lead Belt Chat and 5% 85-100 penetration Asphalt Cement. This averaged 60 pounds to the square yard.

In re-surfacing the granite or brick pavement the same mix was used, requiring 125 pounds per square yard. There are 16 miles of this type of pavement on Broadway.

This work was carried out under the personal direction and supervision of Frank J. McDevitt, Director of Streets and Sewers, City of St. Louis.

New surface was able to bear traffic immediately after compacting!

A survey through the bus companies and taxi cab drivers brought enthusiastic praise of three features of the re-surfaced pavement: *non-skid, non-glare* and *freedom from tire noise.*

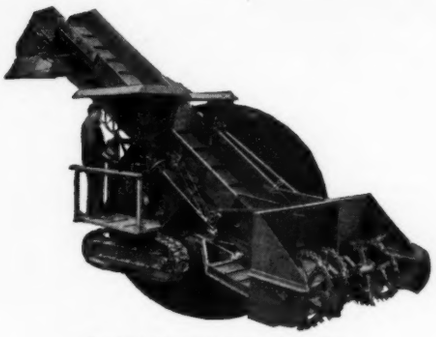
About 100,000 square yards of re-surfacing was done at night from 9 PM to 4 AM. This night work was done on heavy traffic streets with portable stands, using auto headlights. The record for re-surfacing in one night was 2500 square yards, using 12 men.

No seal coat was used on any of this work.

Copr. 1937, Standard Oil Co.

Asphalt for every purpose

STANDARD OIL COMPANY
(INDIANA)



Barber-Greene Snow Loader

New Barber-Greene Spiral Feed Snow Loader

Barber-Greene Company, Aurora, Illinois, have just announced the new Barber-Greene Model 38-D snow loader. This machine has a spiral feed which gives a uniform feed from the full working face, greatly increasing the capacity under tough conditions.

This 1937 model Barber-Greene has a high traveling speed of 2 to 3 miles per hour combined with the positive travel ability of full crawler mounting. It gets to the job site without delay and its many slow crowding speeds allow it always to work at the maximum possible speed.

The capacity of the 38-D calls for only a pause of the truck being loaded. Ten yards a minute is a conservative rating.

One of the most valuable features of this new machine is the side discharge shuttle conveyor, an optional extra. This obviates the need of having trucks back under.

This loader has the added advantage of being easily converted into the Barber-Greene Model 82 Bucket Loader for handling sand, gravel, etc.

Full information and copy of 24-page booklet "Snow Insurance" on request to Barber-Greene Co., Aurora, Ill.

Hauck Speedmaster Kettle

A new tar and asphalt melting kettle has been developed by the Hauck Mfg. Co., Brooklyn, N. Y., in which the conventional firebox is eliminated, the heat from the burner being distributed by a double return tube inside the kettle.

The New Hauck Speedmaster

This results in very fast melting. Another improvement is the "no-freeze" drawoff cock, which is claimed to prevent cold material from clogging the drawoff. The manufacturer claims that this kettle will melt 14 drums of high melting point asphalt or 25 barrels of pitch per 10-hour day in a 75-gallon kettle.

This "Speedmaster" unit is built in 50, 75 and 110-gallon sizes. Ask the manufacturer for catalog sheet No. 654, which describes it fully.

"Auto-Flex" Barricade Supports

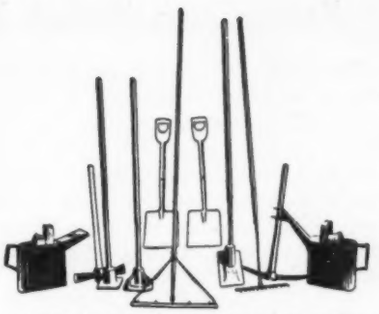
"Auto-Flex" barricade supports derive their name from the fact that they are automatically flexible. Features such as, resistance to wind, to suction and to vibration and allowance for uneven surfaces and for indifference of operators in making application to the boards, are all incorporated in "Auto-Flex" supports, which are made by Stephen L. Dearing, Palmyra, Mo.

The barricade board is held in a suspended position, supported by board-attachments which are suspended from a "hinge-pin" on which the two legs of the support hinge. The head-castings for the legs (malleable) have stops which prevent the legs spreading beyond a fixed distance. The board thus suspended is free to swing to and fro as a sign suspended from a rod. Direct force of wind or suction is exhausted in swinging the board and is not transmitted to the structure as a whole. The swing action of the board is limited only by contact with either leg or the angle between the legs.

Barricade Supports

Four-point bearing of the legs on uneven surfaces is assured through the turning of the head-castings about the hinge-pin, permitting either of the four legs to rest at a point 18" above or below the plane in which the other three legs rest. This feature obviates the difficulty experienced through the carelessness of the indifferent operator.

Board-attachments are designed to accommodate standard 2" boards, S2S —1⅝" thick. In collision the barricade is upset, legs collapse, leaving an obstruction of less than 7" above road surface—a minimum danger hazard. While in the upset position, the small attachment castings are protected and shielded by the larger and stronger head-castings thus reducing probable damage to supports to the legs proper which are lengths of ¾" pipe, connected by pipe couplings.



Some Littleford Tools of value in bituminous road maintenance and construction.

Heating Concrete on Seminole Dam Construction

Concrete for the Seminole dam, Wyoming, is mixed on the top of a hill in a central mixing plant, then carried by tramway bucket down into the canyon to a pumpcrete remixing hopper and pump. Thence it is forced through pipes to the forms and cast.

To offset chilling in this process Littleford concrete heaters have been installed on the pumpcrete remixing hopper on which covers have been provided. There, heat is applied to each bucketful as it is remixed so that it reaches the forms at suitable temperature.

Ransome Pneumatic Concrete Placer:

A pneumatic concrete placer has been announced by the Ransome Concrete Machinery Co., Dunellen, N. J. This is used for placing concrete by pneumatic pressure and the machine is especially adapted for such work as the lining of concrete tunnels. Mixed concrete is charged into the opening after which a horizontal sliding door operated by compressed air seals the intake opening; a worm feed, air driven, forces the concrete into the discharge chamber where air is applied which carries the batch of concrete through the pipe line to the point of deposit.

It is claimed that due to the worm feed construction only a minimum amount of air is required to move the concrete, the number of blocks in the discharge line are materially reduced, the output is increased for given sizes, and headroom, width, and length for a given capacity are reduced to a minimum.

Pneumatic Concrete Placer

American Road Builders' Association

The 1937 convention of the A R B A will be held in New Orleans, La., Jan. 11 to 15. In connection with the convention, a highway exhibit will be held, in which heavy equipment will not be shown, exhibits being limited in weight and size. About 125 manufacturers of equipment and material producers will display their products.

A list of the exhibitors as announced by the officials of the A R B A follows:

Adams Company, J. D.
Air Reduction Sales Company
Allis Chalmers Mfg. Co.
American City Magazine, The
American Concrete Expansion Joint Co.
American Manganese Steel Co.
Anthony Company, Inc.
Armco Culvert Mfrs. Assn.
Asphalt Institute, The
Athey Truss Wheel Company
Atlas Powder Company
Austin Western Road Machinery Co., The

Barber-Greene Company
Barrett Company, The
Bendix Products Corp.
Bendix-Westinghouse Automotive Air Brake Co.
Black & Decker Mfg. Co., The
Blaw-Knox Co.
Bucyrus Erie Co.
Buda Co., The
Budde Tank Co., Inc.

C. H. & E. Mfg. Co., Inc.
Calcium Chloride Assn.
Philip Carey Co., The
Caterpillar Tractor Co.
Chain Belt Company
Chevrolet Motor Co.
Cleaver Brooks Co.
Cleveland Tractor Co., The
Concrete Surfacing Machinery Co., The
Construction Machinery Co.
Continental Motors Corp.
Contractors & Engineers Monthly

VA Lubricant Co., Inc.
Deere & Co.
Dow Chemical Co., The

Eaton Mfg. Co.
Edison Splitdorf Corp.
Etnyre & Co., E. D.
Euclid Road Machinery Co., The
Evans Products Co.

Fairbanks, Morse & Co.
Foote Co., Inc., The
Four Wheel Auto Drive Co., The
Fruehauf Trailer Co.
Fuller Mfg. Co.

Galion Allsteel Body Co., The
Galion Iron Works & Mfg. Co., The
General Electric Co.
General Motors Truck & Coach, Div. of Yellow Truck & Coach Mfg. Co.
Godwin Co., Inc., W. S.
Gorman-Rupp Co., The
Gruendler Crusher & Pulverizer Co.

Harnischfeger Corp.
Heil Co., The
Heltzel Steel Form & Iron Co., The
Hercules Motors Corp.
Hetherington & Berner, Inc.
Highway Steel Products Co.
Hough Co., Frank G., The
Hug Company, The
Hughes Keenan Co., The

Insley Mfg. Corp.
International Harvester Co.
Iowa Mfg. Co.

Jaeger Machine Co., The
Johns-Manville
Johnson Co., C. S.

Keystone Driller Co.
Kinney Mfg. Co.
Koehring Co.
Koppers Co., Tar & Chemical Div.

Laclede Steel Co.
La-Plant Choate Mfg. Co., Inc.
Læschen & Sons Rope Co., A.
Le Tourneau, Inc., R. G.
Lima Locomotive Works, Inc.
Link Belt Co.
Littleford Brothers
Lone Star Cement Corp.
Lufkin Rule Co., The

McGraw Hill Publishing Co.
Macwhyte Co.
Mall Tool Co.
Marion Steam Shovel Co.
Master Vibrator Co.

National Colortype Co., Inc., The
National Paving Brick Assn.
National Traffic Guard Co.
Novo Engine Co.

Osgood Co., The

Pioneer Gravel Equipment Mfg. Co.
Portland Cement Assn.
Public Works Journal Corp.

R. B. Equipment Mfg. Company
Ransome Concrete Machinery Co.
Riddell Corp., W. A.
Roads & Streets

Scintilla Magneto Co., Inc.
St. Paul Hydraulic Hoist Co.
Schramm, Inc.
Servicised Products Corp.
Signal Service Corp.
SKF Industries, Inc.
Smith Co., T. L., The
Solvay Sales Corp.
Speeder Machinery Corp.
Sterling Machinery Corp.

Texas Co., Asphalt Sales Dept., The
Thew Shovel Co., The
Timken Roller Bearing Co., The
Toncan Culvert Mfrs. Assn.
Trackson Company
Truscon Steel Co.
Tuthill Spring Co.

Universal Crusher Co.

Walter Motor Truck Co.
Waukesha Motor Co.
White Mfg. Co.
Wico Electric Co.
Williamsport Wire Rope Co.
Gar Wood Industries, Inc.
Wood Preserving Corp., The
Wright Dalton Machinery Co.

Personal News:

William E. Stanley, for the past 17 years a member of the firm of Greely and Hansen, has been appointed Professor of San. Eng. at Cornell University.

Charles H. Eastwood of Wallace & Tiernan Co., who has been very ill for the past two months is now recovering and will soon be back at work.

H. F. Holbrook has been appointed Vice President and General Manager of the W. A. Riddell Co., Bucyrus, O. Mr. Holbrook has been manager of the company, which has just emerged from receivership.

Riddick Establishes Laboratory

Thomas M. Riddick, formerly associated with the late Nicholas S. Hill, Jr., as chemist and bacteriologist has established laboratories for chemical and bacteriological analyses of water, sewage and milk, and for testing of coal, sand and cement, at 369 East 149th Street, New York City.

Mr. Riddick is also equipped to provide supervision of operation of water and sewage treatment plants and swimming pools, and to make stream pollution investigations, and sanitary surveys. His previous experience includes: Instructor in Sanitary Engineering at New York University; North Carolina State Health Department; North Carolina and Virginia State Highway Departments. He is a member of the American Water Works Association and of the American Society of Civil Engineers, the New York State Sewage Works Association, and American Public Health Association.

Catalogs:

Standard Recorders for Water Level.—A four page folder describing the latest addition to the line of Julien P. Friez & Sons, Inc., Baltimore, Md. Interesting description and details. Especially suited to recording stage at stations where low flow is nearly constant and high flows are flashy. Sent on request.

Ransome Concrete Machinery.—Condensed pocket edition catalog, 2 colors, briefly describes and illustrates the Ransome line. Sent on request to Ransome Concrete Machinery Co., Dunellen, N. J.

Plant-Mixing with Stabilized Aggregates.—A new bulletin, just published by Calcium Chloride Association. 8 pp., well illustrated with charts and diagrams. Sent on request to the Calcium Chloride Assn., Penobscot Bldg., Detroit, Mich.

Speedomatic Shovels.—A new 12-page book describing the advantages of Speed-o-matic controls on Link-Belt shovels, cranes and draglines. Sent on request. Ask for Book No. 1795. Link-Belt Co., 307 No. Michigan Ave., Chicago, Ill.

Diesel Engines. — Cooper-Bessemer Co., Mt. Vernon, O., has issued a bulletin describing their type GN diesel, built in 3, 4, 6 and 8 cylinders, rated 50 to 58 hp. per cylinder. Sent on request. Much interesting technical information.

Mechanical Rubber Goods.—A new 27-page catalog has been issued by B. F. Goodrich Co., Akron, O., covering belting, hose and fittings, tubing, packings, cements, valves, matting and many other items. Sent on request.

Kennedy Valves:

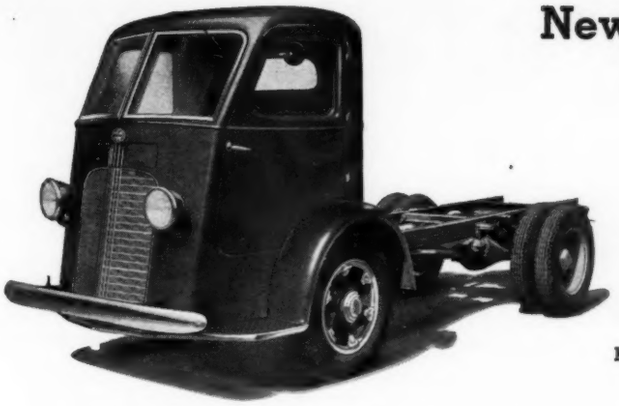
A bulletin describing a new line of fully bronze-bushed standard iron-body wedge gate valves has just been published by The Kennedy Valve Manufacturing Company. This folder contains large sectional views of these valves, with references to 33 outstanding features of design, and describes the valves in detail. A fracture through the valve metal is illustrated to show the exceptionally dense structure, which is 50 per cent stronger than ordinary cast-iron. Other views illustrate the ease of connecting up, operating, repacking, lubricating, and dissembling the valves. Copies of the bulletin may be obtained by addressing The Kennedy Valve Manufacturing Company, Elmira, New York, and asking for Bulletin 47.

Screening and Vibration:

"Data on Controlled Vibration and Screen Efficiency" is a new book which can be obtained from the Productive Equipment Corporation, 4600 South Kedzie Avenue, Chicago, Illinois. Complete data on screening and grading in every industry, charts, data and engineering information, as well as a complete description of "Selectro" Vibrating Screens.

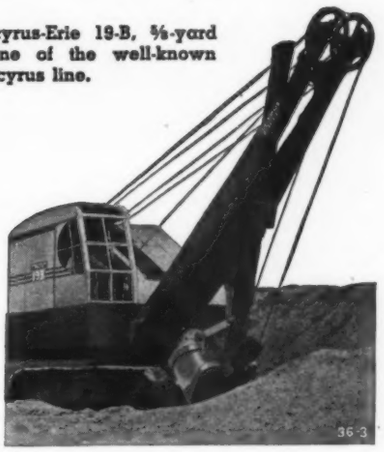
New Ideas Pictorially Presented

On This and The Following Page



Left: International Seat-Over Engine Truck

Right: New Bucyrus-Erie 19-B, ⅝-yard excavator, is one of the well-known Bucyrus line.



International Seat-Over-Engine Truck

International Harvester's new cab-over-engine truck of 1½-ton rated capacity is known as the Model C-300. In this latest International unit the driver is seated directly over the engine, not alongsde the rear of it. All heat and fumes, therefore, pass out beneath the seat at the rear of the cab. Available in 99- and 117-inch wheelbase lengths and is adapted to body lengths up to and including a maximum of 15 feet. Reduction in overall length is about 3 feet.

This secures the ideal weight distribution of 1/3-2/3 between rear and front axles, with more uniform wear on all six tires and greater breaking efficiency, especially on the front wheels due to the increased weight on the front tires.

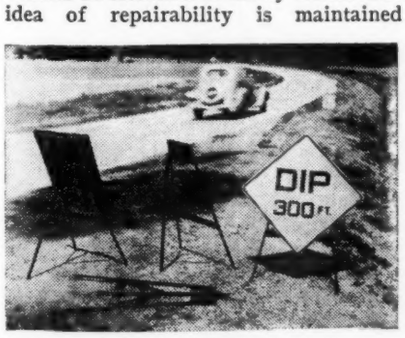
Auto-Flex Sign Easels

The "Auto-Flex" easel or tripod is of arc weld panel, #12 straps on ½" square legs. The prop-leg folds into the panel giving a convenient parcel less than ⅝" in thickness, locks in collapsed position and locks in open or spread position, requiring some force to overcome the action of the locking device.

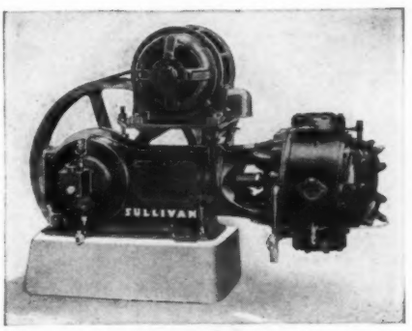
The easel is propped well to the top giving good wind resistance, the locked open prop-leg prevents "walking-up," the common cause of most easels falling forward. To blow this easel over with the wind to the back of it, requires a strong wind and the action must take place in one gust for if not, the prop-leg drops back on its original footing.

The locked-up position of the prop-leg gives assurance of it not coming open at a critical time, a great safety feature on locations of heavy traffic. The idea of repairability is maintained throughout the design and construction of this article. Springs and pins are removable, releasing prop-leg and braces for straightening and clearing the panel.

For further information write Stephen L. Dearing, Palmyra, Mo.



Auto-Flex Sign Easel

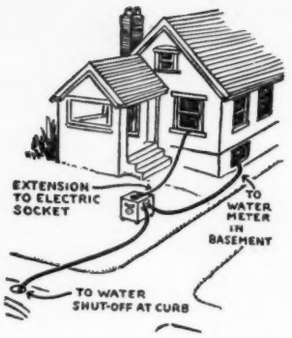


A stationary compressor built in sizes from 10 to 50 h.p., and for pressures of 5 to 150 pounds. Sullivan Machinery Co., Michigan City., Ind.; Bulletin A-13.

New adjustable wrenches, 4- to 12-inch. J. H. Williams Co., 75 Spring St., N. Y., will send dope on request.

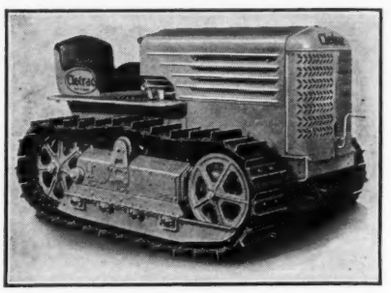
Below: Koehring Long Range Dragline operating on a drainage and channel change project.

A special unit designed and built for the City of Cincinnati by Littleford Bros., Inc., Cincinnati, O. It is a combination supply tank and tool box. The insulated tank holds 550 gallons, has two torch type burners with U-type return heat flues. At each side are two compartments alongside and under the tank to hold the tools needed for the highway repair gang. Vacuum brakes on the rear wheels add safety.



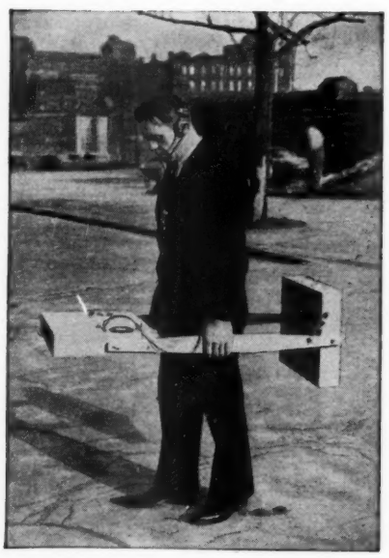
THAWING FROZEN PIPES

This sketch shows very clearly the simplicity of the pipe thawer of The Commonwealth Mfg. Co., 3785 Beechmont, Cincinnati, O. Speedy thawing—easy to reach out-of-way places. Full details on request from manufacturer.



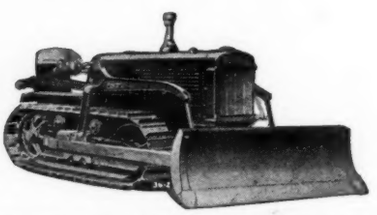
The Cletrac streamlined crawler tractor is a new development that puts tractors in a new style class. Comfort for the operator, too. Cleveland Tractor Co., Cleveland, O., will send booklet on request.

¾-yard; built of high tensile steels by electric welding; considerable weight reduction; standard Allis-Chalmers crawler tractors; dipper is light, too, of all-welded construction. Available with light alloy steel attachments for service as shovel, dragline, crane, skimmer scoop, trench hoe and piledriver. Just announced by the Harnischfeger Corp., Milwaukee, Wisc.

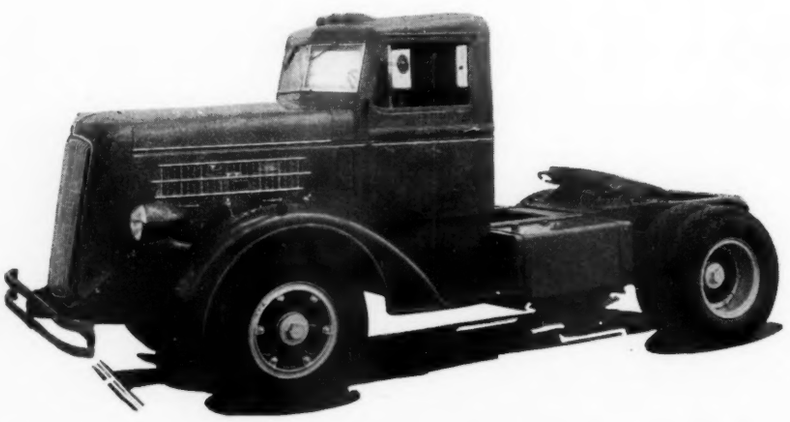


The M-Scope locates and determines the depth of buried pipes, valves, manholes, or cables without electrical contact with the ground or object to be located. For further data write to Fisher Research Laboratories Sales Company, 45 Rockefeller Plaza, New York.

The Osgood "Invader" is a new ⅜-yard shovel just announced by the Osgood Co., Marion, O. This is full-revolving, chain-crowd, easily convertible to dragline, crane, back-hoe or skimmer. It weighs 23,700 pounds; crawler tread; speed from 1 to 4 m.p.h.; 6-cylinder engine. Excellent booklet sent on request.



The "Bullgrader," a new product of the Bucyrus-Erie Co., serves the double purpose of grading and bulldozing. Blade may be angled quickly right or left, set straight or tilted. Also effective for snow removal. New bulldozer also has been announced. For data write Bucyrus-Erie Co., So. Milwaukee, Wisc.



The FWD Model T-40 tractor truck shown above is designed for heavy duty hauling at high speeds. It has a gross capacity of 40,000 pounds.

Weight 45 lbs.; 21" high. Dry, wet and blower styles. You can use three of these on a compressor now running 2 55-lb. drills, giving ⅓ more drilling. This is an Ingersoll - Rand Jackhammer.